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ADDITIONS TO THE U. S. NAVY—BATTLESHIPS KEARSARGE AND KENTUCKY.

Our naval fighting strength will soon be increased by the additions of the battleships *Kearsarge* and *Kentucky*, both of which have undergone their acceptance trials and are now receiving their proper equipment for naval service. In our engraving the *Kentucky* is shown steaming full speed ahead during her recent sea speed trials. Both these vessels were built at the Newport News yard and they are practically alike in all essential particulars. Their most peculiar feature is the superimposed turrets forward and aft, the larger and lower turrets, each carrying two 13-in. breech loaders, and the upper turrets each containing two 8-in. breech loaders. In addition in the main battery the vessels carry, broadside, fourteen 5-in. rapid fire guns, and in the secondary battery twenty 6-pounders and eight 1-pounder rapid fire guns, and also the usual automatic and field guns. The defensive powers are provided for by a side belt of Harveyized armor of a maximum thickness of 16 1-2 in. and armor plate disposed else-

U. S. BATTLESHIP KENTUCKY STEAMING "FULL SPEED AHEAD" ON HER TRIAL TRIP.
(Original photograph, Copyright, 1899, by N. L. Stebbins, Boston, Mass.)

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where for the protection of the ship's vitals. The protective deck is 2 3-4 in. thick.

In former issues we gave the chief dimensions of these vessels and now add some particulars regarding the machinery equipment. They are twin screw vessels with engines of about 10,000 I. H. P. The engines are vertical inverted triple expansion, with wrought steel framing thoroughly trussed and stayed, and with cylinders, 33 1-2 in., 51 in., and 78 in. dia., and 48 in. stroke. Single ported piston valves are used throughout, one for the H. P., two for the I. P., and four for the L. P. cylinders. Stephenson's link motion is used for all valves. Steel forgings are extensively used for the working parts and the line, thrust and propeller shafts are hollow forged nickel steel. Independent pumps are fitted for all services. Manganese bronze is used for the propellers, which are three bladed, true screws, 16 ft. 9 in. dia. and with pitch adjustable from 16 ft. to 18 ft.

Fire tube cylindrical boilers are used; three double ended and two single ended, all 15 ft. 8 in. diameter.

Auxiliaries are numerous, covering a large number of pumps for a great variety of purposes from boiler feed to sanitary service; also ice machine, distilling apparatus, etc. A more general application of electricity for power purposes has been made on these ships than on any other of our naval vessels. The installation was the subject of a special paper read before the Society of Naval Architects and Marine Engineers, reported in our last issue.

Both these vessels have attained a speed considerably in excess of the contract 16 knots on trial. In his report the Secretary of the Navy announces that the *Kearsarge* will be completed for service this month and the *Kentucky* next month.

On trial the battleship *Kentucky* attained a speed of 16.897 knots, and the *Kearsarge* on trial attained a rate of 16.85 knots.

A. S. M .E. Meeting.—Members of the American Society of Mechanical Engineers met in New York December 5, on the occasion of the twentieth annual meeting. The presidential address by George W. Melville, Engineer-in-Chief of the Navy, treated of "Engineering the United States Navy; its Personnel and Matériel." A number of valuable papers on a variety of engineering subjects was read and discussed. Excursions to local points of interest, power plants, etc., were arranged for and participated in largely by the members. The social side of the meeting is always a strong one with the mechanical engineers, and besides excursions, other pleasant functions formed part of the programme. The solicitation of funds for the provision of a suitable memorial to Robert Fulton was actively carried out by a special committee appointed for that purpose. The remains of the great engineer lie in the Trinity Church grave yard in New York city, and arrangements have been made with the church authorities for the placing of the memorial. C. H. Morgan was elected President to succeed George W. Melville. We purpose in an early issue to republish the address of the retiring President. Charles H. Morgan, the new President, has long been connected with the steel and wire industry and is associated now with a company in Massachusetts bearing his name.

CAUSES FOR THE ADOPTION OF WATER TUBE BOILERS IN THE U. S. NAVY.*

BY GEO. W. MELVILLE, ENGINEER-IN-CHIEF, U. S. N.

It has been a number of years since I have had the honor and pleasure of addressing this Society. Speaking generally, the progress and design of machinery of warships has been during that time along such well-developed lines, and so in accordance with the generally accepted theories of designers, that there has been little to say. More recently, however, in order to keep pace with the times and to cope with the necessity we have always before us of securing ships that will be in nowise inferior of those built for any other nations, a change in machinery design has been made that at first glance appears radical—the general adoption of water tube boilers for all new vessels of our Navy.

Elsewhere violent diatribes have been launched against those responsible for a similar decision, and I am aware that there exists a not inconsiderable sentiment in this country against water tube boilers. I call it a sentiment advisedly, because I believe that much of it is due to the attachment that engineers have for their old and proved friend, the cylindrical boiler.

Only a part of the opinions unfavorable to the change arises from the natural and proper conservatism of naval architects and marine engineers, but these demand answer. Flooded always with new devices—or, rather, by rejuvenated failures in new forms—we find a very small proportion that is even worthy of a trial; and where a new mechanical idea is tried on shipboard so much time is spent in adapting it to naval conditions and in repairing its failures that each of us becomes naturally and properly dubious when any change is suggested. Any important change in design, even of the apparently minor fittings of ships, may involve such risk to vessel and crew as to be unjustifiable, unless the device be thoroughly tried beforehand. Many apparently good ideas have given successful results on shore only to fail dismally at sea. I think that it may be given as a general rule that no change in design should be authorized that has not already been successfully made.

Of course, a strict application of the foregoing rule would lead to stagnation. Here, however, enters the designer. His role is an important one. He has to cull the good points from previous work, and if he be a good designer he must also leave out the bad points. There always are some bad points, but amelioration of conditions should be the aim of naval designers. This implies that a good designer must be of vast experience and of extended observation. The larger his field of observation the more valuable his conclusions. It is the details that count. No man can succeed as a designer of warships without the most careful attention to small things.

The modern battleship is a monument to the greatness of the minutiæ of design. It has been gradually built up from the sailing beauties of a century ago. Steps in advance have been slow, generally speaking. We cannot advance by leaps and bounds in marine work. Here genius is hampered by such conditions as make any step in advance a great achievement. Of course, we

* Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York.

have the case of Ericsson and the *Monitor*, but this was a case not only of special conditions, but also of a most exceptional man. Naval architecture is a pyramid, each stone of which is supported by all of the preceding ones. The size of the stone that one man can add to the pile depends, of course, upon his ability, but more especially upon his work. By hard work and by paying attention to what is going on around him any man can add his quota; but "those who, having eyes, see not; and who, having ears, hear not," are worse than useless.

The task I have set myself to-day is no mean one. I desire to show that the decision to use nothing but water tube boilers in our future war vessels is a step in advance, and that it is a natural step towards the evolution of the perfect fighting machine. I desire to show that it is no radical change, and that it does not involve the use of anything but a tried, successful and reliable apparatus that gives us positive and great advantages over the character of boilers heretofore generally used. I desire not to minimize the disadvantages following this change, but to show that these disadvantages are not only not insurmountable, but for warships they have already been overcome.

In the first place, I want to state that water tube boilers are bad in principle. They carry the pressure inside their weakest parts—the tubes. A failure in a tube is followed by the opening of a fault, sometimes to a dangerous degree. In a fire tube boiler, on the contrary, the pressure would continue to close a split tube. It is true that a failure of a boiler tube generally comes from pitting, where fire tube boilers generally have such a great advantage as in cases of split tubes. Yet failure of tubes is the most common defect in all boilers, and a proper design would place the pressure on the outside of the tube. Water tube boilers are, from their very definition, designed from a wrong principle, not only because of the direction of application of pressure upon the tubes, but also on account of the decreased amount of water in the boiler, of the increased difficulty of observing a leak, and of the decreased value of heating surface in water tube boilers. For this reason, as an engineer, it is with some misgiving that I state that I consider water tube boilers tactical necessities for warships.

Builders of water tube boilers use solid-drawn tubes almost exclusively for marine work. This, of course, decreases the danger of split tubes, but it does not change the mechanical principle. Some day, probably not in my time, we may hope to have a boiler having fire tubes and having the advantages of water tube boilers. Such a boiler would force its way at once into all navies, just as water tube boilers are doing at the present day.

Disbelieving, as I do, in the cardinal principles of water tube boilers, I have sturdily opposed their adoption by our Navy, until now I am convinced that they must be used if we are not going to content ourselves with inferior ships to those built for other nations. Of course, during the period of development of the design of water tube boilers, that even now continues, I have in my official capacity kept track of and taken part in the world-wide experiments with their use. Water tube boilers have advantages, and I have never been blind to them. Two years ago I stated that their disadvantages had been sufficiently removed to justify their use on our warships. Now I consider that the value of their advantages has been sufficiently developed to necessitate their use, if we do not wish to be left behind in naval design.

The principal thing to which I desire to call your attention is the fact that all vessels are essentially compromises. Any ship must be considered in its entirety, and the advisability of a change in design of any part must be determined from its effect upon the ship as a whole. Whether or not water tube boilers are superior to cylindrical boilers as boilers simply, if there be a beneficial effect upon the ship as a whole due to the adoption of water tube boilers, these boilers are essential to the best design.

The necessity of compromise in ship design must be self-evident to the members of this Society, who have the problem before them for solution almost daily. Taking the particular case of warships, the size of our ships is limited by their draft. We are building vessels now that are as large as any that can enter our harbors and docks, and we cannot, therefore, increase their power as fighting ships except by improvements in design. Any increase in weight allotted to one essential of the efficiency of the ship must be counter-balanced by a decrease in some other perhaps equally essential element. So far this has most frequently been done by robbing the coal pile—an extra gun, a half knot in speed, or an additional inch in armor protection—each mean a few tons less coal in the bunkers. I must except the more recent designs of battleships from the above general rules. The importance of coal endurance has become more and more manifest, and it has been appreciated fully in our recent designs. Incidentally, these last ships are fitted with water tube boilers.

Water tube boilers are considerably lighter than those of the old type, and their effect upon ship design may be given as follows: Of two ships having all other qualities identical, one fitted with cylindrical boilers and the other with water tube boilers, the latter will be somewhat the smaller and handier—will have somewhat less draught, and will cost less.

Limited, as we are, in the size of our warships by their draught, I think that the foregoing shows that for a maximum of fighting efficiency we must use water tube boilers. The designing engineers of our naval vessels are limited in weight and space. They save little or nothing in space, perhaps, but they save greatly in weight if they adopt water tube boilers. If these can be successfully operated on shipboard they must be used because of their decreased weight. The foregoing is entirely apart from any consideration of the relative merits of water tube and fire tube boilers, but it is conditional upon the possibility of the successful operation of water tube boilers.

Before considering claimed advantages and disadvantages of water tube boilers, I desire to give a few historical facts, most of them already well known to the members of this Society.

The old Martin boiler was the first water tube boiler ever used in any naval vessel. We had good success with these boilers, but they died out of use with the introduction of high-pressure multiple-expansion engines, and the consequent cylindrical boilers.

For years none but water tube boilers have been in-

stalled in our steam launches. These have always been attended by unskilled labor, yet the results have been very satisfactory. Some accidents have occurred, but they have been very few, probably no greater in number than if fire tube boilers had been used; and it is to be noted that the results of a boiler explosion would probably have been worse in almost every case if the failure had occurred in a fire tube boiler.

Torpedo-boats and destroyers in our Navy have always, since the time of the *Cushing*, been equipped with water tube boilers of various types. Small bent tube boilers have generally been used. There have been some cases of sad accidents in the fire-rooms, generally due to carelessness in manufacture, and particularly in tube setting, but not to defective design. The boilers have proved to be quite as reliable as the extremely light engines of these boats. With the small amount of skilled attention it is possible to give torpedo-boats, and considering the character of service demanded of these small craft, I think that no engineer will to-day question that the use of light water tube boilers, with the higher speeds possible as a result, adds to their efficiency and security. I think even Herr Schichau has come to be of this opinion.

The first large installation of water tube boilers in our Navy was on the *Monterey*. Indeed, at the time this was the largest installation of water tube boilers in any navy. In this monitor, as you all know, there are four round Ward water tube boilers, with two cylindrical single-ended fire tube boilers. The water tube boilers have been satisfactory. It is worthy of note that there has been very little difficulty experienced in maintaining a steady water level, although the boilers have a very small amount of contained water. Tubes have failed by pitting several times, though never with any danger to the firemen. The water tube boilers have been twice retubed by the ship's force without laying the ship up at any navy yard. On one occasion, probably with a view to thoroughly testing the water tube boilers, or to satisfy the unholy desires of some person decrying water tube boilers, the ship made a voyage of about 8,000 knots, largely under forced draught, and whenever possible with all boilers in use. There was no resultant injury to the water tube boilers, which performed well throughout the trial. The combustion chambers of the cylindrical boilers came out of the trial badly bulged.

The Yarrow boilers of the *Nashville* have operated fairly successfully, though they cannot be said to be completely satisfactory, on account of the amount of trouble given by bulging of drums and by leaky tubes. The first set of copper tubes has been replaced by others of steel to considerable advantage. I believe that the latest designs of this type of boiler provide for the use of slightly curved tubes next the fire. This ought to be advantageous.

The *Marietta's* trip around South America at the beginning of the war with Spain was quite as successful as was that of the Oregon. The first ship is fitted with Babcock & Wilcox boilers, the second with cylindrical boilers. No repairs were required to either set of boilers after the completion of the trip.

The *Annapolis* is also equipped with Babcock & Wilcox boilers, and here, as on the *Marietta*, these boilers have been thoroughly successful. Indeed, a former chief engineer of the *Annapolis* has stated to me that the boilers of that ship were easier to manage in use and easier to maintain in a state of high efficiency than are cylindrical boilers.

The *Chicago* has several Babcock & Wilcox boilers, and these have so far worked in a thoroughly satisfactory manner, no failure being reported under any circumstances.

The foregoing represents the tried installations of water tube boilers in ships larger than torpedo-boats and destroyers in the United States Navy. Babcock & Wilcox boilers of the shore or stationary type were installed in the old monitors *Canonicus, Mahopac*, and *Manhattan*, the old rectangular boilers being entirely worn out and it being deemed advisable to fit these old boats for whatever service they could do. The change was commenced at the beginning of the Spanish war. Before its close the change was complete, and a somewhat greater speed was attained than with the original boilers. This change was made without injuring the decks of the monitors. The old boilers were cut up and passed out through the smokestack, down which the parts of the new boilers were passed, the latter being assembled in the engine-room space. This is an instance where none but water tube boilers could have been used, and where every facility of repair and installation was of enormous advantage. For naval vessels with their protective decks the facility with which water tube boilers can be removed or completely renewed without disturbing the decks may of itself justify us in adopting water tube boilers.

There are building and repairing several other ships of our Navy, to be fitted with partial or complete outfits of water tube boilers. These include the *Alert, Atlanta, Cincinnati, Wyoming* (Babcock & Wilcox), *Maine* and *Connecticut* (Niclausse), *Missouri, Wisconsin*, and *Arkansas* (Thornycroft), and *Florida* (modified Normand).

The foregoing gives the installation of water tube boilers in our Navy from which data has been obtained. So far as tried, the boilers have invariably been easy of operation, though I have found more skill required to obtain the best results from these boilers than would have been necessary if cylindrical boilers had been used. Particular attention has been given in all cases to the feed arrangements. Water tube boilers must have ample feed pumps, and the regulation of the feed must be easy. At first the heating surface of water tube boilers was made 3 sq. ft. per horse power, against 2 sq. ft. necessary with cylindrical boilers. This figure has been gradually reduced, until now we are down to 2.4 sq. ft. of heating surface per horse power, about as low as I think it is yet safe to go with water tube boilers.

The economical results from water tube boilers were at first not particularly good. At present we get quite as good results from water tube boilers of the latest design as from the best cylindrical boilers. The ratio of heating surface to grate surface has been kept up to at least 40, although we do not yet feel warranted in allowing as small grate surfaces in water tube boilers as in cylindrical boilers. Water tube boilers lose in efficiency when forced, especially those of the straight-tube type. Of course, this is not of very great moment to us in a naval vessel, which is under forced draught only at

maximum speed, but it is, nevertheless, a disadvantage.

The following table shows the relative economy of cylindrical and water tube boilers:

	Annapolis.	Marietta.	Newport.	Princeton.	Vicksburg.	Wheeling.
Type and number of boilers....	(2 B. & W.)		(2 single-ended cylindrical.)			
Displacement (tons).....	1,000	1,000	1 000	1,000	1,000	1,000
Knots per ton of coal at most economical speed.....	26.38	22.27	18	19.6	21.25	16.6
Number of scr'ws	1	2	1	1	1	2
Grate surface (sq. ft.).....	98	94	78	78	78	60
Heating surface (sq. ft.).....	3,620	3,664	2,524	2,524	2,524	2,508

The increased grate surface we have required with water tube boilers will be a positive advantage to our ships' steaming qualities. I consider that sustained sea speed depends largely upon the grate surface. Heating surface, of course, must be provided, but I should prefer an excess of grate surface to an exceedingly high ratio of heating surface to grate.

Up to this time we have had no trouble from salt water or grease in water tube boilers. Indeed, we could hardly be more troubled by salt water with this type of boiler than we have been with cylindrical boilers. We suffered severely in our short war with Spain from dropped furnaces in cylindrical boilers. I do not think that a properly designed water tube boiler will give more trouble from the use of impure feed water, such as sometimes we must have at sea, than any other boiler. I do not think tubes more liable than furnaces to fail from a deposit of scale. In any event, the evaporating plants of all our ships are being made adequate to give fresh feed water. The only danger of salt water in the future should come from leaky condensers.

Glancing abroad for a moment, we find every modern naval power, from England to Japan, committed to the use of water tube boilers on the largest scale. Each of these countries has had its experience, and each has decided not only that water tube boilers can be worked, but also that they work well and that they must be used in naval vessels.

I will give a few observations on the working of various types of water tube boilers abroad. The result of a first glance would seem to be that anything would do to make steam, from Watt's tea-kettle to the most complicated of modern steam generators. I know of one French boiler (you know what ingenious mechanics the French are) composed equally of water and fire tubes. The tubes were concentric, and the distance between them but one millimeter. Of course, the amount of water is very small—so small as to put this boiler in the class called by their originators "inexplosible." This boiler was tried at the works of the maker with good results. It was next tried in a torpedo-boat with equally remarkable results—seven men killed, I believe.

We have read of explosions, however, of really well-designed water tube boilers. Generally it is found that a tube had failed, and that the furnace door was open—the result, more or less fatal burns to all in the fire-room. We hear of all the failures, but the successes are never mentioned. It is not difficult to foresee the failure of a boiler plant designed to furnish 120,000 pounds of steam per hour, but regularly required to furnish 160,000 pounds per hour. If nothing else fails, the feed pumps will not do the work, and the tubes will, of course, be burnt out. This would happen with any type of boiler.

You see, I harp on the failures, for I find I can glean the most information from them. Many of the failures have come from the use of boilers that were inaccessible for cleaning and repairs; others from faultv design; others from poor workmanship; others, again, from neglect. Water tube boilers require skilled attendance. Other boilers have failed from poor material; others from failure of the feed pumps; but there is not one, so far as I know, that can properly be said to have failed purely as a result of being a water tube boiler. Failures may come from misusing water tube boilers, but not from using them. I consider that the experience of the last ten years or more in our own and in foreign navies justifies me in stating that water tube boilers, when proper precautions are used, can be successfully adopted for the steam generating plant of ocean-going vessels. They are necessities to the best design of warships.

I would naturally come now to a discussion of the claims of the adherents and opponents of water tube boilers. You have all heard these arguments, and it seems almost useless to go over them. I shall simply state what I believe to be the advantages and disadvantages of water tube boilers compared with cylindrical boilers:

Advantages.	Disadvantages.
Less weight of water.	Greater danger from failure of tubes.
Quicker steamers.	Better feed arrangements necessary.
Quicker response to change in amount of steam required.	Greater skill required in management.
Greater freedom of expansion.	Units too small.
Higher cruising speed.	Greater grate surface and heating surface required.
More perfect circulation.	Less reserve in form of water in boiler.
Adaptability to high pressures.	Large number of parts.
Smaller steam pipes and fittings.	Tubes difficult of access.
Greater ease of repair.	Large number of joints.
Greater ease of installation.	More danger of priming.
Greater elasticity of design.	
Less danger from explosion.	

A saving in space has been claimed for water tube boilers, but I do not find this claim sound when account is taken of the increase in grate and heating surface necessary in water tube boilers to ensure satisfactory working, and because of small units the space for accessibility is increased rather than diminished.

The fact that water tube boilers raise steam quickly is of the greatest advantage. I have stated elsewhere that I consider the battle of Santiago to have developed the necessity of the use of water tube boilers whether it taught us anything else or not. It would have been of the greatest advantage to have had during the blockade of Santiago boilers capable of raising steam in less than half an hour. Coal need not have been used to keep all the boilers under steam all the time. The *Massachusetts* might have shared in the glories of the fight if she had been fitted with water tube boilers. The *Indiana* would have kept up with the *Oregon* and the *Texas*. The *New York* would have developed at least three knots more speed, and the Navy would have been spared a controversy. I think the

Colon would not have gotten as far away as she did. But we did not have the water tube boilers.

The higher pressures possible with water tube boilers give us smaller and safe steam pipes and better valves. It decreases the size of the fittings and the difficulty of tracing the labyrinth of a ship's piping. It increases the efficiency of the engines. The introduction of compound engines forced us to use cylindrical boilers. In the same way the use of quadruple expansion engines necessitates, for economy, the use of water tube boilers.

But the quick steam raiser is, because of that very fact, not so safe as its predecessor. Of course, nothing on a man-of-war is very safe in war time, but we want things as safe as possible, and the boilers are the keys to the situation in the modern battleship. I think that safety in handling water tube boilers may be assured by using skill in the fire-rooms. I have more than ten years' successful experience with water tube boilers on which to found this opinion, and I submit that the boilers, placed as they are behind the heaviest armor and below the thick protective deck, are, at the worst, the safest apparatus on a battleship. If we can make them work well we would do wrong to refuse to use water tube boilers on our ships.

For merchant and for yacht practice it is a different question. I was recently asked what boilers to use in a large steam yacht. I recommended cylindrical boilers. For merchant work the boilers are always in use, developing a fixed power. Weight is not there so important as in warships, and I think it is at best a moot question whether cylindrical boilers are not still the best that can be fitted in ocean-going merchantmen. In some cases where there are short trips and the opportunities for repair must be gotten during the very short lay-ups at the end of the route, the quick steam raising qualities of water tube boilers, with their freedom of expansion, enables blowing down the boiler immediately on arrival in port and still having steam at an hour's notice on all boilers. Such cases as this seem to me to demand water tube boilers.

As to the type of boiler to be used there are as many to choose from as there are fleas on a dog. Some one has said that a certain amount of fleas keep a dog from brooding over being a dog. So the number of varieties we have to choose from may be a good thing for all.

I have always opposed the use of boilers containing screw joints in contact with the fire, and have attempted to secure boilers having no cast metal in the pressure parts. Cast steel is not yet good enough to put between 300 pounds of steam and our firemen. I believe in straight-tube boilers, as being easier of examination and repair than bent-tube boilers. I believe in large tube boilers for the same reason, and because the tubes are thicker and have more margin for corrosion. I believe in boilers having as few joints as possible. Water tube boilers must have freedom of expansion of the various parts, and the simpler the boiler the better. It should not be necessary to introduce reducing valves between the boilers and the engines to secure a steady steam pressure at the latter, nor should it be necessary to have automatic feed arrangements to ensure steady water level in the boilers. To be successful a boiler must be easy of repair. Lightness is a natural attribute of all water tube boilers, but it is not wise to go too far in this direction. The ratio of grate surface to fire surface occupied for the complete boiler plant must be as large as possible. The units should be large, the grates short and not too wide. The passage of gases through the tubes should be sufficiently long to ensure economy. These gases should be well mixed before entering the spaces between the tubes for the same reason, and to prevent smoke. The circulation of the water in the boiler must be free. Tubes should not be too long, and the fire-rooms must always be sufficiently wide to provide for free withdrawal.

The foregoing is what we want. We have most of the above desiderata in several well-known types of boilers and ultimately we shall discover the value of each of the foregoing points, and then it will be possible to differentiate between the various types more perfectly than we now can.

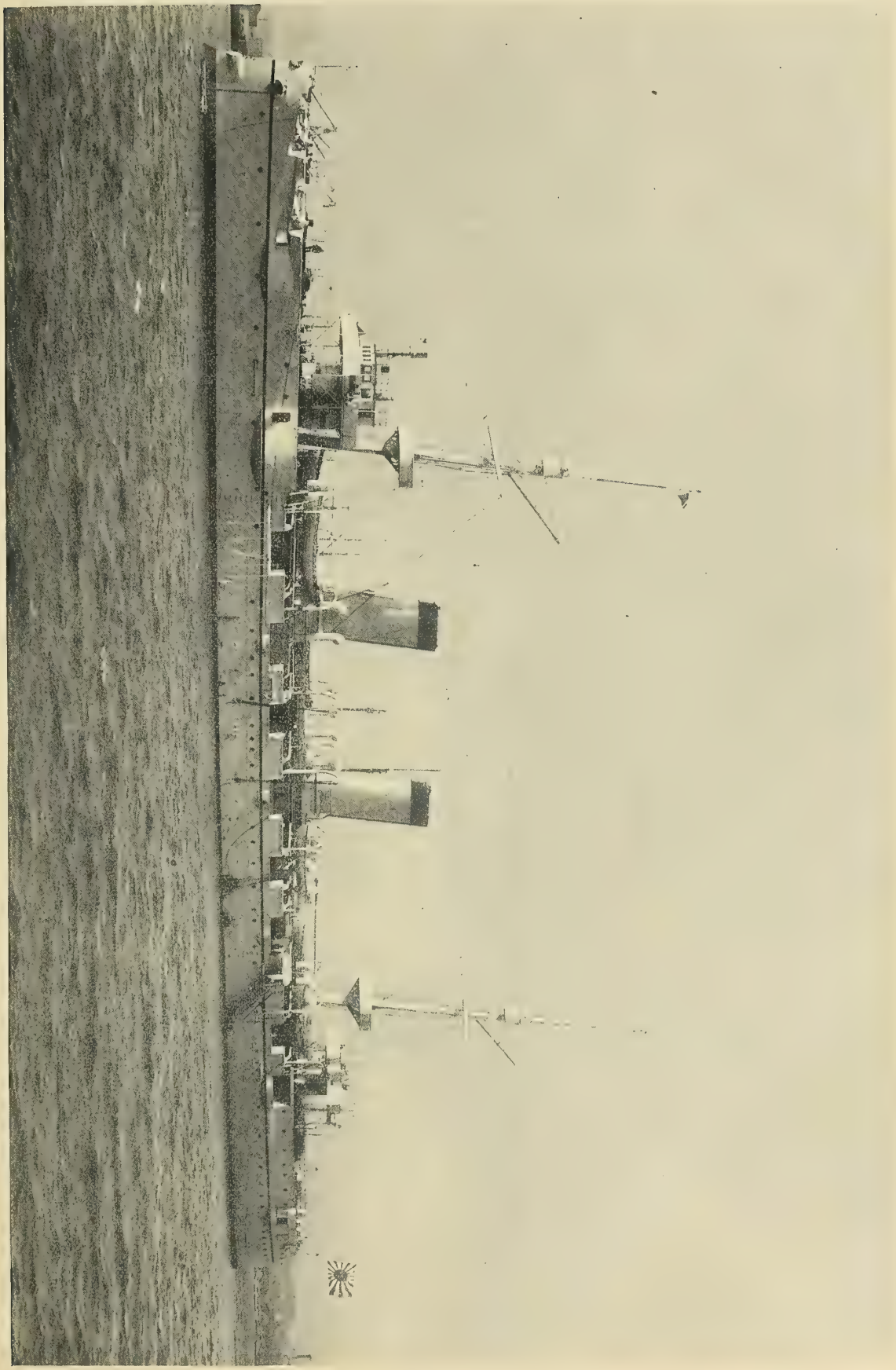
In the meantime, all that I have to say is that the use of water tube boilers has been definitely decided upon for our naval vessels, because water tube boilers give tactical advantages of great moment, and because, with care in selection, manufacture and management of water tube boilers, other disadvantages may be neutralized.

Japanese Cruiser Chitose.

On the opposite page we give a view of the Japanese cruiser *Chitose*, built by the Union Iron Works, San Francisco, and which has recently successfully undergone her acceptance trials in Japanese waters. The results have been highly satisfactory, as on the trial an average speed of 21.5 knots (natural draft) was maintained ,while the contract called for a rate of speed one knot less. Under the terms of the contract, we are informed, the acceptance of the vessel by the Japanese Government was not to take place until March next, but the naval officers reported so favorably on the *Chitose* that she has been accepted and the final payments made to the builders. The *Chitose* is therefore now in commission attached to the Japanese home squadron.

The *Chitose* is a steel protected cruiser of these dimensions: Length, 376 ft. 5 in.; beam, 49 ft., and draft, normal, 17 ft. 7 in., with a displacement of about 4,700 tons. She is fitted with twin screws driven by triple expansion engines of 15,500 I. H. P.—maximum. Steam is supplied by cylindrical return tube boilers, four double ended and four single ended. She has a protected deck of 4 1-2 in. maximum thickness. Her armament, which was supplied by the Armstrong's and was fitted in place in Japan, consists of two 8-in. guns, one forward and one aft, protected by shields; ten 4.7-in. guns, twelve 12-pounders, twelve 6-pounders, and six 1-pounder. All are of the rapid fire pattern. She has also five torpedo tubes. Her cost complete was about $1,500,000. A sister ship, the *Kasagi*, was built by the Cramp's for the Japanese navy.

Quick work was done on the British battleship *Venerable* launched recently, the vessel having been launched just eight months from the time she was laid down at Chatham Dock Yard. Her launching weight was 5,200 tons. The vessel when completed will displace 15,000 tons and will have a trial speed of 18 knots. Her armament will consist of four 12-in., twelve 6-in., sixteen 12-pounders and a number of machine and small guns.



JAPANESE PROTECTED CRUISER CHITOSE—4,700 TONS, 15,500 I. H. P.—BUILT AND ENGINED BY THE UNION IRON WORKS, SAN FRANCISCO, CAL.

CONSIDERATION OF THE STEAM YACHT FROM THE DESIGNER'S POINT OF VIEW.—III.

BY WILLIAM A. FAIRBURN.

In general appearance the steam yacht of to-day still resembles somewhat the yacht of twelve or more years ago. The earlier yachts, however, were fitted with a single deck house forward and later with two houses, one forward and one aft, with low machinery casings amidship. A large number of British yachts had their solitary house nearer amidships and this was often connected to the machinery casings. About 1893 one large deck house running over half the length of the vessel began to take the place of the small and separate deck houses. The *Eleanor* was the first large steam yacht which had this feature. A year later the *Giralda* appeared with a similar deck house, but the top of the house ran out to the side of the vessel, thus forming a shade deck and a most desirable promenade above. The *Giralda* was also the first yacht to be fitted with a topgallant forecastle. The latest Watson designed boats instead of having the usual deck house with a passage between it and the rail, have the deck house extending out to the side, thus forming a continuation of the shell of the vessel. By this arrangement splendid accommodation is obtained on the main deck. It is, however, questionable as to which arrangement of deck houses is preferable: The Watson *Mayflower* style, or the British *Giralda* and American *Aphrodite* style, in which there is a deck space of about 6 ft. between the rail and the house on either side. While the latter arrangement somehow narrows the rooms, it has the compensating advantage of a clear view forward from the quarter deck the length of the ship, instead of a vista of deck houses. It also gives an unbroken promenade from stem to stern and, as the top of the deck house runs out to the side of the vessel, there is still the spacious unbroken promenade above. If the yachtsman desires his vessel for cruising, deep sea work and genuine yachting, he would probably prefer the latter arrangement; but if for coasting, receptions and social functions, the latest Watson arrangement would undoubtedly please him the most.

Considerable controversy has appeared of late in a few yachting papers, criticizing the general appearance of various American steam yachts. The writer will not here make any plea for American designed and built yachts, but he will say, and this most forcibly, that there are men in America to-day capable of designing steam yachts which, in appearance, accommodation and seagoing qualities, will be equal to the best production of foreign designers. It is about time for the patriotism of American yachtsmen to assert itself so that we can build American designed steam yachts for American owners.

Many yachts on both sides of the Atlantic could without doubt be classed as failures. The design of a steam yacht by the majority of shipbuilding firms is not given the strict attention and careful consideration which it is entitled to, and that is why there are so many naval architects to-day who make a specialty of yacht design. The most skilful naval architect cannot design a truly handsome, successful, steam yacht if he is not thoroughly in sympathy with his work. He needs to be schooled to the work. His judgment must be good and his taste such that all the lines of the vessel harmonize with each other. Many a pleasure craft to-day has graceful endings—bow and stern—very pleasing to the eye when viewed separately, but when placed on the same vessel they lack harmony and fail to balance. The combination of the sheer, bow and stern is generally what determines the appearance of the yacht, but much also depends on location and rake of spars, stack, etc., and the arrangement of the deck work.

On a steam yacht much has to be sacrificed in order to get a fine appearance. All private owned steam yachts afloat to-day possess but one smokestack or funnel, and the latest fad of yacht owners is to make this elliptical and as "powerful" looking as possible. The earliest full powered yachts had a schooner rig with standing gaffs. Now the British vessels are usually supplied with fitted topmasts, sliding French gaffs, bowsprit and jibboom; whilst the American vessels which have no pretense of sail power are fitted with pole masts, French sliding gaffs and spike bowsprits. Pole masts with leg of mutton sails are gaining in popularity. The French gaffs are always carried low, only just high enough to clear the awnings and being peaked they are very pleasing to the eye. A single yard on the foremast is also peculiar to British designed steam yachts. The early auxiliary steam yachts had a fore and aft schooner rig, and they have been through all the stages of barkentine, brigantine, barque and brig, to the full ship rig.

Although quite a large number of the yachts afloat to-day have the owner's accommodation on the lower deck forward, yet the modern practice is to place the owner and his guests aft, and give the forward lower deck to the officers and crew. Sometimes the owner and his guests are given the best of the space both forward and aft of the machinery spaces. When this is the case the officers are located aft and the crew forward—an arrangement that has many advantages. The deck house on the large vessels is usually divided up into reception room, dining room, owner's private rooms, galley pantry, laundry and machinery casings. The latest boats have a large chart room, captain's stateroom and smoking room above the deck house on the shade deck, and the top of this house forms a bridge running out to the side of the ship.

From the foregoing one might be given the impression that steam yachts are designed principally for appearance and accommodation. This to a great extent is true, but the all-important matter of seaworthiness and easiness in a seaway is of vital importance. Modern sea going yachts are being given great flare to the bow above water and good freeboard. Bilge keels are also beginning to be adopted. The *Aphrodite* is practically a non-roller, she having bilge keels with an area of about 280 sq. ft. each. Many persons have the impression that a steam yacht necessarily means a vessel of light scantlings, but this is not the case, for whilst small craft of high speed have of necessity light scantlings bordering on torpedo boat construction, yet ocean going yachts to be insured must be classed by one of the standard registration societies, of which the best known are probably the British Lloyd's, Bureau Veritas, and the American Bureau of Shipping. These societies have until recently insisted on scantlings for

large yachts as heavy as put into merchant vessels of the same dimensions. For instance, many a sea going steam yacht has been built according to the American Bureau or U. S. Standard rules, with scantlings as heavy as required for a cargo steamer of the same outside dimensions, but almost twice the displacement, and yet the steam yacht possesses a much superior shape when viewed from a strength standpoint. She has a natural, strong, easy shape. Lloyd's allow somewhat for this difference, as they consider the girth of the midship section—as will also the new 1900 rules of the American Bureau of Shipping—but it must be acknowledged that the ocean going steam yachts are about the strongest vessels afloat, especially if the classification societies allow the designer to judiciously arrange some of the material so as to get maximum efficiency with the weight allowed.

Much has been said, especially of late, concerning the steam yacht as a naval auxiliary. In time of war the full powered steam yacht will undoubtedly prove an acquisition to the Navy, acting as a dispatch and special service vessel. Some of the converted steam yachts did good work off Cuba in the late war. The high speed yacht built for sound and coast work has been, and may continue to be, a very popular vessel in America, and these vessels having fair accommodations, high speed, light draft, good manœuvring qualities and ability to rapidly get up steam, could probably with little expense be converted into torpedo or patrol vessels in case of an emergency, provided they are not too small; for the general dimensions, the model, and the motive power, are about the same for the fast yacht as for the torpedo boat. Nevertheless, well designed pleasure yachts will not make first-class war vessels and these vessels should only be thought of as auxiliaries, being used only when war vessels cannot be procured.

The cost of a steam yacht is a very variable quantity, as fully 40 per cent of the cost may be due to the owner's whims and fancies in selecting magnificent furnishings for his yacht. But few people have any conception of the cost of a steam yacht. Even a little steam or naptha launch costs from $1,000 to $5,000. A small steam yacht like the *Oberon* costs about $7,000, and this vessel is no larger than many a launch. A yacht fit for fair weather coasting is very cheap at $18,000, and the majority of this class exceed this figure by a good deal. It is said that the *Illawarra*, 106 ft. long and 12 knots speed, cost about $60,000; the *Free Lance*, 108 ft. long and 16 knots, $65,000; the *Peregrine*, 131 ft. long and 14 knots, $95,000; the *Electra*, $125,000; and the builders of the *Atalanta*, *Eleanor* and *Corsair* received about $200,000 each for the construction of these vessels. It is said John Jacob Astor paid $240,000 for the *Nourmahal*; the *Varuna* cost Eugene Higgins about $300,000, and the *Aphrodite* yacht has cost Col. Payne $360,000. These prices are for the boats complete, with the exception of the fittings and furnishings and equipment furnished by the owner. The largest yachts afloat to-day are probably worth from $400,000 to $600,000 complete, with all furnishings on board. But initial cost is not all that must be considered, for it costs a fortune every year to keep any of these large pleasure craft in commission, the running expenses of the larger vessels varying from $8,000 to $15,000 per month, and sometimes when there is much entertaining even more.

Year by year larger and finer steam yachts are being constructed. As we study the magnificent vessels afloat to-day it seems as if the limit of size and excellence of design has been reached. But this is not so, for progress must yet be made, and even to-day designers must confess that their productions are not perfect—they are the best that could be produced under existing conditions. The adoption of water tube boilers in ocean going vessels, before many years, will greatly assist the yacht designer, for it is in the machinery and propulsion of these vessels that there is the greatest room for improvement. Nevertheless, the modern steam yacht is an artistic, mechanical and practical production, and worthy of the admiration and approbation of all interested in Naval Architecture and Marine Engineering.

Obituary.

Commander Charles P. Howell, who was chief engineer of the battleship *Maine* when she was blown up in Havana harbor February 15, 1898, died at his residence in New York, December 7. He expired suddenly from an apoplectic stroke. Commander Howell was born in Goshen, N. Y., fifty years ago, and he was graduated from the Naval Academy in June, 1868, fourth in his class. He had attained the rank of chief engineer under the old organization and under the operation of the Personnel Bill was made a commander in September last. At the time of his death Commander Howell was on duty at the New York Navy Yard. The funeral was carried out with military honors, the Reverend Doctor McKelway, chaplain of the training ship *Vermont*, officiating. The Episcopal Church service was used. The interment took place at Goshen, N. Y.

About the time of our going to press last month the death of Thomas H. Ismay was announced. Mr. Ismay was widely known as the founder and chairman of the White Star line. When he first became identified with that line it consisted entirely of sailing ships in the Australian trade, but when transatlantic trade was decided upon an order for a steamship, the original *Oceanic* was placed with Harland and Wolff, at Belfast. These builders have constructed the entire fleet of the White Star line; and such were the relations between Mr. Ismay and others in the management of the White Star line and the firm of Harland and Wolff, that no contract was ever made between them for the construction of any of these vessels. Under Mr. Ismay's directions the company expended about $35,000,000 in steamships since the early seventies. Mr. Ismay resided in Liverpool and was identified with many public enterprises.

Dixon Kemp, the famous English authority on yachts and yachting, died recently in England, aged sixty years. Mr. Kemp was largely responsible for the establishment of Lloyds yacht register and for many years he was the yachting editor of the English publication known as the *Field*.

Reverend E. L. Berthon died recently in England at an advanced age. He was best known as the inventor of the collapsible boat which bore his name, though he was the inventor of a variety of devices, some for marine use.

REVIEW OF PAST PROGRESS IN STEAM NAVIGATION AND FORECAST OF FUTURE DEVELOPMENT.*—II.

BY SIR WILLIAM WHITE, CONSTRUCTOR-IN-CHIEF, R. N.

ADVANTAGES OF INCREASED DIMENSIONS.

Before passing on it may be interesting to illustrate the gain in economy of propulsion resulting from increase in dimensions by means of the following table, which gives particulars of a number of typical cruisers, all of compartively recent design:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Length, feet	280	300	360	435	500
Breadth, feet	35	43	60	69	71
Mean draught, feet	13	16½	23¾	24½	26¼
Displacement, tons	1,800	3,400	7,400	11,000	14,200
Indicated horse-power for 20 knots	6,000	9,000	11,000	14,000	15,500
Indicated horse-power per ton of displacement	3.3	2.65	1.48	1.27	1.09

The figures given are the results of actual trials, and embody, therefore, the efficiencies of propelling machinery, propellers and forms of the individual ships. Even so they are instructive. Comparing the first and last, for example, it will be seen that while the displacement is increased nearly eightfold, the power for 20 knots is only increased about 2.6 times. If the same types of engines and boilers had been adopted in these two vessels—which was not the case, of course—the weights of propelling apparatus and coal for a given distance would have been proportional to the respective powers; that is to say, the larger vessel would have been equipped with only 2.6 times the weight carried by the smaller. On the other hand, roughly speaking, the disposable weights, after providing for hulls and fittings in these two vessels, might be considered to be proportional to their displacements. As a matter of fact this assumption is distinctly in favor of the smaller ship. Adopting it, the larger vessel would have about eight times the disposable weight of the smaller; while the demand for propelling apparatus and fuel would be only 2.6 times that of the smaller vessel. There would, therefore, be an enormous margin of carrying power in comparison with displacement in the larger vessel. This might be devoted, and in fact was devoted, partly to the attainment of a speed considerably exceeding 20 knots—which was a maximum for the smaller vessel—partly to increased coal endurance, and partly to protection and armament.

Another interesting comparison may be made between vessels Nos. 4 and 5 in the preceding table, by tracing the growth in power necessary to drive the vessels at speeds ranging from 10 knots up to 22 knots:

Knots.	No. 4. Horse-power.	No. 5. Horse-power.
10	1,500	1,800
12	2,500	3,100
14	4,000	5,000
16	6,000	7,500
18	9,000	11,000
20	14,000	15,500
22	23,000	23,000

It will be noted that up to the speed of 18 knots there is a fairly constant ratio between the powers required to drive the two ships. As the speeds are increased the larger ship gains, and at 22 knots the same power is required in both ships. The smaller vessel, as a matter of fact, was designed for a maximum speed of 20 1-2 knots, and the larger for 22 knots. Unless other qualities had been sacrificed neither space nor weight could have been found in the smaller vessel for machinery and coals corresponding to 22 knots. The figures are interesting, however, as illustrations of the principle that economy of propulsion is favored by increase in dimensions as speeds are raised.

Going a step further, it may be assumed that in unsheathed cruisers of this class about 40 per cent of the displacement will be required for the hull and fittings, so that the balance, or "disposable weight," would be about 60 per cent, say 6,600 tons for the smaller vessel, and 8,500 tons for the larger, a gain of nearly 2,000 tons for the latter. If the speed of 22 knots were secured in both ships, with machinery and boilers of the same type, the larger ship would, therefore, have about 2,000 tons greater weight available for coals, armament, armor and equipment.

These illustrations of well-known principles have been given simply for the assistance of those not familiar with the subject, and they need not be carried further. More general treatment of the subject based on experimental and theoretical investigation will be found in text-books of naval architecture, but would be out of place in this address.

SWIFT TORPEDO VESSELS.

Torpedo flotillas are comparatively recent additions to war fleets. The first torpedo boat was built by Mr. Thornycroft for the Norwegian navy in 1873, and the same gentleman built the first torpedo boat for the royal navy in 1877. The construction of the larger class, known as "torpedo boat destroyers," dates from 1893. These various classes furnish some of the most notable examples extant of the attainment of extraordinarily high speeds for short periods, and in smooth water, by vessels of small dimensions. Their qualities and performances, therefore, merit examination. Mr. Thornycroft may justly be considered the pioneer in this class of work. Greatly impressed by the combination of lightness and power embodied in railway locomotives, Mr. Thornycroft applied similar principles to the propulsion of small boats, and obtained remarkably high speeds. His work became more widely known when the results were published of a series of trials, conducted in 1872 by Sir Frederick Bramwell, on a small vessel named the *Miranda*. She was only 45 ft. long, and weighed four tons, yet she exceeded 16 knots on trial. The Norwegian torpedo boat, built in 1873, was 57 ft. long, 7 1-2 tons, and of 15 knots; the first English torpedo boat of 1877 was 81 ft. long, 29 tons, and attained 18 1-2 knots. Mr. Yarrow also undertobk the construction of small swift vessels at a very early date, and has greatly distinguished himself throughout the development of the torpedo flotilla. Messrs. White, of Cowes, previously well known as builders of steamboats for use on board ships, extended their operations to the construction of torpedo boats. These three firms for a considerable time practically monopolized this special class of work in this country. Abroad they had able competitors in Normand in France, Schichau in Germany, and Herreshoff in the United States. Keen competition led to successive improvements, and rapid rise in speed.

During the last six years the demand for a fleet of about one hundred destroyers, to be built in the short-

*From a paper read before the British Association, Mechanical Science Section.

est possible time, involved the necessity for increasing the sources of supply. At the invitation of the Admiralty a considerable number of the leading shipbuilding and engineering firms have undertaken, and successfully carried through, the construction of destroyers varying from 26 to 33 knots in speed, although the work was necessarily of a novel character, involving many difficulties. As the speeds of torpedo vessels have risen, so have their dimensions increased.

Within the class, the law shown to hold good in larger vessels applies equally. In 1877 a first-class torpedo boat was 81 ft. long, under 30 tons weight, developed 400 horse power, and steamed 18 1-2 knots. Ten years later the corresponding class of boat was 135 ft. long, 125 tons weight, developed 1,500 horse power, and steamed 23 knots. In 1897 it had grown to 150 ft. in length, 140 to 150 tons, 2,000 horse power, and 26 knots. Destroyers are not yet of seven years' standing, but they come under the rule. The first examples —1893—were 180 ft. long, 240 tons, 4,000 horse power, and 26 to 27 knots. They were followed by 30-knot vessels, 200 ft. to 210 ft. long, 280 to 300 tons, 5,500 to 6,000 horse power. Vessels now in construction are to attain 32 to 33 knots, their lengths being about 230 ft., displacements 360 to 380 tons, and engine power 8,000 to 10,000 horse power.

Cost has gone up with size and power, and the limit of progress in this direction will probably be fixed by financial considerations rather than by constructive difficulties, great as these are as speeds rise. It may be interesting to summarize the distinctive features of torpedo vessel design:

(1) The propelling apparatus is excessively light in proportion to the maximum power developed. Water-tube boilers are now universally adopted, and on speed trials they are "forced" to a considerable extent. High steam pressures are used. The engines are run at a high rate of revolution—often at 400 revolutions per minute. Great care is taken in every detail to economize weight. Speed trials at maximum power only extend over three hours. On such trials in a destroyer each ton weight of propelling apparatus produces about 45 indicated horse power. Some idea of the relative lightness of the destroyer's machinery and boilers will be obtained when it is stated that in a large modern cruiser with water-tube boilers, high steam pressure and quick-running engines, the maximum power obtained on an eight hours' trial corresponds to about 12 indicated horse power per ton of engines, boilers, etc. That is to say, the proportion of power to weight of propelling apparatus is from three and a half to four times as great in the destroyer as it is in the cruiser.

(2) A very large percentage of the total weight—or displacement—of a torpedo vessel is assigned to propelling apparatus. In a destroyer of 30 knots trial speed, nearly one-half the total weight is devoted to machinery, boilers, etc. In the swiftest cruisers of large size, the corresponding allocation of weight is less than 20 per cent of the displacement, and in the largest and fastest mail steamers it is about 20 to 25 per cent.

(3) The torpedo vessel carries a relatively small load of fuel, equipment, etc. Taking a 30-knot destroyer, for example, the speed trials are made with a load not exceeding 12 to 14 per cent of the displacement. In a swift cruiser the corresponding load would be from 40 to 45 per cent, or proportionately more than three times as great. What this difference means may be illustrated by two statements. If the load were trebled, and the vessel correspondingly increased in draft and weight, the speed attained with the same maximum power would be about three knots less. If, on the other hand, the vessel were designed to attain 30 knots on trial with the heavier load, her displacement would probably be increased about 70 to 80 per cent.

(4) The hull and fittings of the torpedo vessel are exceedingly light in relation to the dimensions and engine power. For many parts of the structure steel of high tensile strength is used. Throughout the utmost care is taken to economize weight. In small vessels, for special service, many conditions can be accepted which would be inadmissible in larger sea-going vessels. The result of all this care is the production of hull-structures having ample general strength, but very little local strength; but notwithstanding all the accidents of navigation and collisions that have occurred in this class of vessel—and they have not been few—not one has yet foundered at sea.

These conditions are essential to the attainment of very high speeds for short periods. They resemble the conditions ruling the design of cross-channel steamers, so far as relative lightness of propelling apparatus, small load, and light scantlings are concerned. The essential differences lie in the requirements for passenger accommodation as compared with the requirements for armament of the torpedo vessel. No one has yet proposed to extend the torpedo vessel system to sea-going ships of large dimensions. Very similar conditions for the propelling apparatus have been accepted in a few cruisers of considerable dimensions, wherein high speeds for short periods were required. It is, however, unquestionable that in many ways, and particularly in regard to machinery design, the construction of torpedo vessels has greatly influenced that of larger ships.

One important consideration must not be overlooked. For short-distance steaming at high speeds economy in coal consumption is of little practical importance, and it is all-important to secure lightness of propelling apparatus in relation to power. For long-distance steaming, on the contrary, economy in coal consumption is of primary importance; and savings in weight of propelling apparatus, even of considerable amount, may be undesirable if they involve increased coal consumption. Differences of opinion prevail as to the real economy of fuel obtainable with boilers and engines such as are fitted to torpedo vessels. Claims are made for some vessels which represent remarkable economy. Only enlarged experience can settle these questions. Endurance is also an important quality in sea-going ships of large size; not merely in structures, but in propelling apparatus. The extreme lightness essential in torpedo vessels obviously does not favor endurance, if high powers are frequently or continuously required. Still, it cannot be denied that the results obtained in torpedo vessels show such a wide departure from those usual in sea-going ships as to suggest the possibility of some intermediate type of propelling apparatus applicable to large sea-going ships, and securing sufficient

durability and economy of fuel in association with further savings of weight.

THE PARSONS TURBO-MOTOR.

This rotary engine, introduced by Charles Algernon Parsons, with its very high rate of revolution, reduces the weights of machinery, shafting and propellers greatly below the weight required in the quickest running engines of the reciprocating type. This reduction in the proportion of weight to power carries with it, of course, the possibility of higher speed in a vessel of given dimensions, and when large powers are employed the absolute gain is very great. An illustration of this has been given by Mr. Parsons in the *Turbinia*. That remarkable vessel is 100 ft. long and of 44 1-2 tons displacement, but she has attained 33 to 34 knots in short runs. There are three shafts, each carrying three screw propellers, each shaft driven by a steam turbine making over 2,000 revolutions at full speed, when an aggregate of more than 2,000 horse power is developed. A water-tube boiler of special design supplies steam of 175 lb. pressure, and is exceptionally light for the steam produced, being highly forced. The whole weight of machinery and boiler is 22 tons; in other words, about 100 horse power indicated is produced for each ton weight of propelling apparatus. This is rather more than twice the proportion of power to weight as compared with the lightest machinery and boilers fitted in torpedo boats and destroyers. It will be noted that in the *Turbinia*, as in the destroyers, about half the total weight is devoted to propelling apparatus, and in both instances the load carried is relatively small.

The secret of the extraordinary speed is to be found in the extreme lightness of propelling apparatus and small load. No doubt in the *Turbinia* lightness has been pushed further than it would be in vessels of larger size and greater power. In such vessels a lower rate of revolution would probably be accepted, additional motors would be fitted for manœuvring and going astern, boilers of relatively greater weight would be adopted, and other changes made. But after making ample allowance for all such increases in weight, it is unquestionable that considerable economies must be possible with rotary engines. Two other vessels of the destroyer type with turbo-motors—one for the royal navy—are now approaching completion. Their trials will be of great interest, as they will furnish a direct comparison with vessels of similar size and form, fitted with similar boilers and driven by reciprocating engines.

On the side of coal consumption Mr. Parsons claims at least equality with the best triple-expansion engines. Into the other advantages attending the use of rotary engines it is not necessary now to enter. Reference must be made, however, to one matter in which Mr. Parsons has done valuable and original work. In torpedo vessels of high speed the choice of the most efficient propellers has always been a matter of difficulty, and the solution of the problem has in many instances involved extensive experimental trials. By means of alteration in propellers alone very large increases in speed have been effected; and, even now, there are difficulties to be faced. When Mr. Parsons adopted the extraordinary speed of revolution just named for the *Turbinia*, he went far beyond all experience and precedent, and had to face unknown conditions. He has found the solution, after much patient and original investigation, in the use of multiple screws of small diameter. His results in this direction are of general interest to all who have to deal with screw propulsion. Such radical changes in propelling machinery as are involved in the adoption of turbo-motors must necessarily be subjected to thorough test before they will be widely adopted.

The experiment which the Admiralty are making is not on a small scale as regards power. Although it is made in a destroyer, about 10,000 horse power will probably be developed, and a correspondingly high speed attained. It may well happen that from this experiment very far-reaching effects may follow. Mr. Parsons himself has prepared many designs illustrating various applications of the system to sea-going cross-channel and special service vessels. Where shallowness of draft is unavoidable, the small diameter of the screws possible with the quick-running turbines is clearly an important matter.

COMPARISONS BETWEEN LARGE AND SMALL VESSELS.

It has been shown that the attainment of very high speeds by vessels of small size involves many conditions not applicable to large sea-going steamships. But it is equally true that in many ways the trials of small swift vessels constitute model experiments, from which interesting information may be obtained as to what would be involved in driving ships of large size at speeds much exceeding any of which we have experience. When the progressive steam trials of such small vessels can be studied, side by side with experiments made on models to determine their resistance at various speeds, then the fullest information is obtained, and the best guide to progress secured. This advantage, as has been said, we owe to William Froude. His contributions to the "Reports" of the British Association are classics in the literature of the resistance and propulsion of ships. In 1874 he practically exhausted the subject of frictional resistance so far as it is known, and his presidential address to this section in 1875 dealt fully and lucidly with the modern or stream-line theory of resistance. No doubt there would be advantage in extending Froude's experiments on frictional resistance to greater lengths and to ship-shaped forms. It is probable also that dynamomentric determinations of the resistance experienced by ships of modern forms and considerable size when towed at various speeds would be of value if they could be conducted. These extensions of what Froude accomplished are not easily carried out, and in this country the pressure of work on shipbuilding for the royal navy has for many years past taxed to the utmost limits the capacity of the Admiralty experimental establishment, so ably superintended by R. E. Froude, allowing little scope for purely scientific investigations, and making it difficult to deal with the numerous experiments incidental to the designs of actual ships.

Now that Holland, Russia, Italy and the United States have equipped experimental establishments, while Germany and France are taking steps in that direction, we may hope for extensions of purely scientific work and additions to our knowledge. In this direction, however, I am bound to say that much might be done if experimental establishments capable of dealing with questions

of a general nature relating to resistance and propulsion were added to the equipment of some of our universities and colleges. Engineering laboratories have been multiplied, but there is as yet no example of an experimental tank devoted to instruction and research.

It is impossible, and possibly is unnecessary, to attempt in this address any account of Froude's "scale of comparison" between ships and models at "corresponding speeds." But it may be of interest to give a few illustrations of the working of this method, in the form of a contrast between a destroyer of 300 tons, 212 ft. long, capable of steaming 30 knots an hour, and a vessel of similar form enlarged to 765 ft. in length, and 14,100 tons. The ratio of dimensions is here about 3.61 : 1, the ratio of displacements is 47 : 1, and the ratio of corresponding speeds is 1.9 : 1. To 12 knots in the small vessel would correspond 22.8 knots in the large vessel, and the resistance experienced by the large vessel at 22.8 knots—neglecting a correction for friction—should be forty-seven times that of the small vessel at 12 knots. By experiment this resistance for the small vessel was found to be 1.8 ton. Hence, for the large vessel at 22.8 knots, the resistance should be 84.6 tons. This would correspond to an "effective horse power" of over 13,000, or to about 26,000 indicated horse power. The frictional correction would reduce this to about 25,000 horse power, or about 1.8 horse power per ton.

Now, turning to the destroyer, it is found experimentally that at 22.8 knots she experiences a resistance of about eleven tons, corresponding to an effective horse power of over 1,700 horse power and an indicated horse power of about 3,000 horse power; say, 10 horse power per ton, or nearly five and a half times the power per ton required in the larger vessel. This illustrates the economy arising from increased dimensions.

Applying the same process to a speed of 30 knots in the large ship, the corresponding speed in the small ship is 15.8 knots. Her resistance at that speed is experimentally determined to be 3.5 tons, and the resistance of the large ship at 30 knots, neglecting frictional correction, is about 165 tons. The effective horse power of the large ship at 30 knots is, therefore, about 34,000 horse power, corresponding to 68,000 horse power indicated. Allowing for the frictional correction, this would drop to about 62,000 horse power, or 4.4 horse power per ton.

For the destroyer at 30 knots the resistance is about 17 1-2 tons, the effective horse power is 3,600 horse power, and the indicated horse power about 6,000 horse power, or 20 horse power per ton—nearly five times as great as the corresponding power for the large ship. But while the destroyer under her trial conditions actually reaches 30 knots, it is certain that in the large ship neither weight nor space could be found for machinery and boilers of the power required for 30 knots, and of the types usually adopted in large cruisers, in association with an adequate supply of fuel. The explanation of the methods by which the high speed is reached in the destroyer has already been given. Her propelling apparatus is about one-fourth as heavy in relation to its maximum power, and her load is only about one-third as great in relation to the displacement, when compared with the corresponding feautres in the cruiser.

ADDITIONS TO THE TRANSATLANTIC FLEET OF THE FRENCH LINE.

Additions to the fleet of the French line maintaining the mail service between Havre and New York, are to be made in accordance with the governmental (French) convention of 1898. Two new vessels are to be added to the fleet, the *La Lorraine* recently launched at the yards of the Compagnie Générale Transatlantique at Pewhoët-Saint-Nazaire, and a sister ship, the *La Savoi* is to be launched next spring.

Lately the French line put in service the former Hamburg-American liner, *Normannia*, under the new name of *L'Aquitaine*. This vessel was purchased from her German owners by the Spanish Government during the war in Cuba, and was renamed the *Patriota*, the intention being to fit her out as an auxiliary cruiser. It is, we believe, the fact that the work of refitting the vessel was never carried out. At any rate she did not figure in the public eye during the war, and now has gone back to the purposes of peace. Her dimensions are: Length, 520 ft.; beam, 57 ft. 6 in.; depth, molded, 38 ft.; displacement at 24 ft. draft, 11,500 tons. She has twin screws, triple expansion engines of 16,300 I. H. P. and a sea speed of about 18 knots. She was built at the Fairfield yard on the Clyde, and broke the builder's record, in that she was built complete and sent on her trial trip within the space of twelve months. She came out in 1890, and is therefore a comparatively new boat.

The new boats of the company will be considerably larger, and through the courtesy of the New York managers of the French line we are able to give particulars of the one recently launched, the *La Lorraine*. Her principal characteristics are as follows:

Length over all	580 ft.
Beam	60 ft.
Depth	39 ft. 6 in.
Displacement at mean draft of 25 ft. 3 in.	15,200 tons.

Her construction was under the supervision of the Bureau Veritas, is of mild steel throughout, with the special use of a steel of higher grade in certain parts to insure longitudinal rigidity.

There are five decks extending the entire length of the ship with a sixth deck about 330 ft. in length serving to shelter the promenaders of the first and second-class passengers. Above the latter deck are placed the life boats to the number of eighteen, together with the life rafts. Two bridges, one above the other, surmount this sixth deck forward of the two funnels, the upper bridge being about 50 ft. above the mean load water line. Safety against foundering is assured by sixteen transverse water-tight bulkheads, and one longitudinal bulkhead separating the two main engine rooms. A cellular water bottom with a capacity of 1,100 tons provides for the variations needed to insure the stability of the ship under the varied conditions of use.

The motive power comprises two four-cylinder vertical triple expansion engines, with Stephenson valve gear. The cranks are provided with counterbalances to reduce the vibration effects. All the auxiliary machinery is fitted independent of the main engines. The boilers are sixteen in number, single ended, 17 ft. dia. and 10 ft. 9 in. long. Each boiler has four 44 in. furnaces, making a total of 64 fires divided be-

tween four transverse fire rooms. The service pressure is 163 lbs. per square inch. The bunker capacity is 3,000 tons.

The total length of the compartments for boilers, coal bunkers and machinery is about 58 per cent. of the length of the ship.

The accommodations for the first and second-class passengers are in the first between-decks and in the two domes described below. The first between-decks contains, starting from aft, the second-class staterooms for a length of 120 ft. the remainder of the deck to within about 80 ft. from forward being occupied by first-class staterooms, boudoirs for ladies, hair-dressing parlor, bath-rooms, etc. The children's dining room with forty places is also on this deck, and sensibly in the middle of the ship. The grand cylindrical dome, whose length is about 330 ft., contains in the central region of the ship the dining-room or main saloon for first-class passengers. The dimensions of this room are 59 ft. in length by 46 ft. in width. The principal part of the room is occupied by three tables of 42.6 ft. length, with 122 chairs of the usual swiveling type. Sofas are fitted at the sides and small transverse tables to the number of fourteen, each with five places. At the two ends forward and aft are placed sideboards for silver ware, desserts, etc. This room which provides seats for 192 persons at one time is lighted and ventilated by rectangular windows in the walls of the dome, and by a large glazed skylight. A special arrangement comprising air ducts and electric ventilators, is furthermore provided for use in case the windows cannot be opened. Forward of the saloon are found the grand stairway, and special staterooms, while aft the various offices, kitchens, bakery, etc., are located.

The grand upper dome, of equal length with the lower, is placed immediately over it, and contains directly over the grand saloon, the social hall and the reading room, 65.6 ft. in length by 36 ft. in width. The entrance-way for first-class passengers is directly over the entrance to the lower dome. The first-class smoking room is placed at the forward end of this dome and is 46 ft. long by 34.5 ft. wide. It contains seats for 84 persons. Between the smoking room and the grand stairway are placed a number of special staterooms, a private parlor, café, bathrooms, w. c., etc.

The second-class saloon, ladies' room and smoking room are placed in the two superposed domes on the forward part of the poop.

The third-class passengers are lodged in the second between-decks, separate apartments being provided for families and for single women.

The vessel has passenger accommodation as follows: Special and extra special, 59; saloon, 378; intermediate, 118; steerage, 398. The personnel is made up of: Officers, 22; sailors, firemen, etc., 192; stewards, servants, etc., 158.

On 6 hours' trial the *La Lorraine* is expected to make 22 knots speed with 22,000 I.H.P. Armament, when fitted out as an auxiliary cruiser, includes nine 5.5-in. rapid firers and eight machine guns of large caliber.

The estimated cost is $2,316,000.

The company will shortly put on two large freight steamships for the New York route. These are recently built British vessels and will be known as the *Bordeaux* and *Pauillac*.

SHIPBUILDING PLANT OF THE UNION IRON WORKS AT SAN FRANCISCO.*

The Union Iron Works, where the famous battleship *Oregon* was built, is the largest engineering establishment on the Pacific Coast, and one of the largest and best equipped marine engineering plants in America. The works have been in existence, under different names, since 1849. Originally their chief product was stationary work, mining machinery being a specialty, and many of the great pumps and hoisting engines of the famous Comstock lode were built at these works. The present shops were built in 1883, and the first steamship, a coasting vessel called the *Arago*, was completed in 1884. She was also the first iron ship built on the Pacific Coast.

The works are located at San Francisco, and cover an area of 28 acres, with a frontage of 1,900 ft. on San Francisco Bay. They are completely prepared to build and fit out steel steamships of any size, and the magnificient equipment of the various shops must be seen to be appreciated. The main buildings, such as foundry, machine, boiler, blacksmith and erecting shops, are fireproof, having iron frames and brick walls with few upper floors or galleries, the most of the work being done on the ground floor. The shops are connected with each other, and to the shipyard by a system of tracks on which steam traveling cranes afford easy and rapid transfer of work from the shop cranes to the 100-ton shears on the dock. Facilities for handling work is a point on which particular care has been exercised.

The iron foundry is a building 90 ft. by 100 ft. It has three cupolas, the largest of which is of 50 tons capacity. Castings of 60 tons weight have been made, and work of twice that size could be poured if necessary. The shop is provided with two overhead cranes, one a pneumatic crane of 50 tons capacity, and one 15 ton electric crane. The walls are also lined with hydraulic jib cranes for lighter work. At present 140 men are employed in this department. There is also a brass foundry employing 60 men, in which six tons can be poured at one time. This is a very busy shop, as the firm makes a great deal of brass work, such as valves and marine fittings, that most shops buy from special manufacturers. It is fitted with an overhead electric crane of 12 tons capacity.

The machine shop is 200 ft. square, covered with a roof of iron and glass, and very well lighted from the sides as well. It is divided by the columns that support the roof into five aisles. The largest of the machine tools are arranged along the sides of one of these aisles. Two of them, the great vertical boring mill, and the combination planing and slotting machine, are of home manufacture and are worthy of special notice. The former can bore and turn, simultaneously, a wheel 30 ft. dia. with 10 ft. face. The boring device is entirely independent of the turning mechanism, and, boring can be done equally as well, whether the table rotates or not. Several tools can be run at once, when turning wide faces, and the work is very accurate for such a large tool. The combination planing machine was designed for facing off large surfaces, such as engine beds.

*From our own special correspondent.

It can finish a surface 20 ft. by 30 ft. at one setting, the tool cutting on both strokes, either up and down, or forward and backward horizontally. Besides these, there is in this aisle a planing machine of the ordinary type, that can surface a piece 10 ft. square and 22 ft. long; a Bement Miles lathe that can swing 125 in. 40 ft. between centers; another lathe of 120 in. swing 50 ft. between centers; a radial drill of 10 ft. radius; and a large slotting machine. Two 40-ton overhead electric cranes, running on the same track, handle the work in this aisle. Tools considerably smaller, but large enough to be classed as very large ones in most shops, are arranged in another aisle over which run two 20-ton electric cranes; while yet another aisle is occupied by tools still smaller, which are served by two 5-ton overhead electric cranes operated from the floor, and running on the same track. The small tools fill the remaining aisles, and also a gallery built over one of them. In this gallery a great many brass finishing tools are placed to finish the product of the brass foundry already mentioned. The arrangement of the tools throughout the shop is very fine, and the facilities for handling work excellent. The overhead cranes are supplemented by hydraulic jib cranes for light work, and car tracks run both ways of the shop. There are a great many special tools, not often seen in similar shops, and many portable tools are operated by either air, hydraulic or electricity. About 300 men are employed in the machine shop.

A portion of the shop has been set apart for an electrical department, which, under the able supervision of the Chief Electrician, W. W. Hanscom, has, from a small beginning, grown to be a department of great importance. It is well supplied with the necessary tools and employs, in the shops and outside, about 130 men. The department has its own corps of draftsmen, and complete electric lighting installments, and all such naval auxiliaries as ammunition hoists, etc., are here designed and built.

The erecting shop is separate from the machine shop, and is fitted up especially for the purpose. The erecting is all done on the ground floor, which is 90 ft. by 200 ft., and is divided into two parts, lengthwise, one for heavy and one for light work. Over the former runs two 50-ton electric cranes, while over the latter are two 5-ton cranes of the same type. A large portion of the floor is made of surfaced cast iron sole plates, which rest on solid foundations, and are provided with T slots for bolting down the work under erection. Pits are provided for work having large flywheels, and a portion of the floor is set apart for testing purposes. Here the proper connections are provided for testing all kinds of work, with either pneumatic, hydraulic or steam pressure, and here also all the small engines are tested by actual running. A great number of these engines are turned out, as this concern, unlike many others, builds all its own auxiliary engines for forced draft, ventilation and the like.

The pattern shop is a four-story brick building, the three upper stories of which are literally filled with patterns. About 40 men are employed.

The blacksmith shop has 24 fires and employs 60 men. It has a good equipment of hydraulic jib cranes for handling heavy work under the hammers.

WATER FRONT VIEW OF THE SHIPYARD OF THE UNION IRON WORKS, SAN FRANCISCO, CAL.—FRAME WORK OVER BUILDING SLIPS AT RIGHT OF PHOTOGRAPH.

The boiler shop is a new building, 90 ft. by 200 ft., with a flanging shop 60 ft. by 100 ft. attached. The frame is of steel, the walls of brick, and the interior is particularly well arranged and equipped. It contains some large tools, among which might be mentioned the large hydraulic riveter, with 12 ft. gap; the vertical bending rolls, that can roll 1 3-4 in. plate 10 ft. wide; the horizontal rolls, that can bend 1 1-4 in. plate 18 ft. wide; and the guillotine shears, that can shear 88 in. of 1 in. plate at one cut. There is also a new boiler shell drilling machine, in which a 16 ft. boiler can be set up on end and five drilling heads, each head operating three drills, can be worked simultaneously upon it. Flanging is done with a large Tweddell hydraulic flanging machine, circular flanges are beveled on a large milling machine made for the purpose, and manholes in heavy plate are cut with an elliptical boring machine or manhole cutter. There is a fine assortment of punches, shears, gang drills, etc., and plenty of hydraulic jib cranes for handling the light work. Two 50 ton, overhead electric cranes, traveling on the same track, do the handling in the main shop, and the two large riveters have overhead traveling cranes of their own. All the large shears, punches, rolls, etc., are driven by independent motors. At present, twelve Thornycroft boilers are in course of construction, in a temporary shop, adjoining the boiler shop, which has been fitted up for that purpose, and several very ingenious special tools may be seen at work here.

In the shipyard are seven slips of different sizes. Four of them have wooden frameworks erected over them, as seen in the accompanying illustration, the largest being 80 ft. by 470 ft. in the clear. Two electric cranes run side by side along the entire length of these frameworks, above the ship, under construction. Each crane covers half the ship, and plates or beams can be handled with ease on any part of the vessel. The furnaces and bending floors have cranes for handling the heavy work, and ribs for the largest ships can be bent without difficulty. The shipsmith shop alone employs 70 men, and has its own outfit of three steam hammers, bolt and rivet making machinery, and furnaces for the same. There is also a 300 ton hydraulic forging press, of home manufacture, with furnaces and overhead crane to suit. Besides the many necessary punches, shears, etc., there are six plate planing machines, from 16 to 24 ft. stroke, large bending rolls, that can bend 1 1-2 in. plate 22 ft. 6 in. wide, and two hydraulic bending machines for bending plates cold. One of these benders, also of home production, is a monster machine, which can take in plates 22 ft. 6 in. long between the uprights, and exerts a pressure of 600 tons. The bedplate weighs 60 tons, and the upper or bending beam weighs 40 tons. Many portable tools are in operation, driven either by air, hydraulic or electricity, and the equipment throughout is very complete and well arranged.

Near the yard is the hydraulic lift dock,[1] and also the 100 ton shears, already referred to. This last is operated by electricity, and is a very convenient appliance.

There is also in connection with the yard a galvanizing plant, boat shops, joiner shop, copper shop and sail loft, in fact, every department necessary for fitting out ships in detail.

[1] See Vol. IV, page 189.

The motive power of the works is obtained from a central power station, in which are installed two 400 H.P. vertical triple expansion engines, and two 100 H.P. engines of the same type, all direct connected to dynamos. Nearly everything, including the electric lighting system, is driven from this central station. The large tools throughout the works are driven by independent motors, and nearly all the line shafting, driving groups of machines, is driven in a similar manner. The engines, dynamos, and nearly all of the 225 motors, used in distributing power throughout the works, are of home design and manufacture, and are first-class in every respect.

The plant has its own pneumatic and hydraulic systems, both of which are very comprehensive, and operate hundreds of stationary and portable tools.

The latest addition to the works is a converter plant for making steel castings. The cupola, and a 2-ton Tropenas converter, is already erected, and will soon be ready for operation.

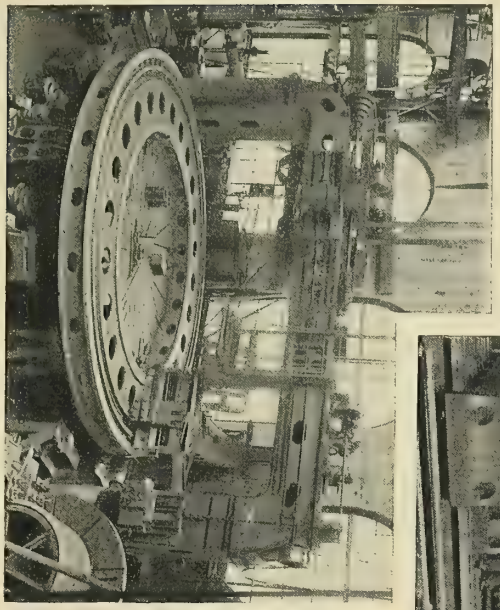
The office building is a new four-story brick structure, 40 ft. by 190 ft. The entire third floor is one room, and is used as a drafting room, in which 60 men are at work. About 3,000 men are now employed by the firm, including the force at the branch works, where the most of their mining work is now done.

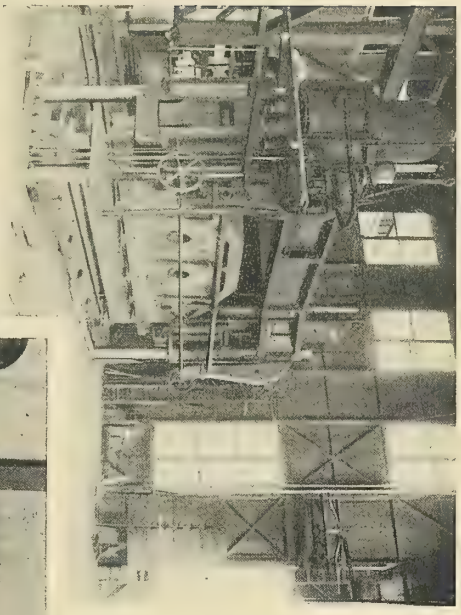
Many merchant ships, tugs, and small craft have been built at this yard, and a number of vessels for the United States Government, including the cruisers *Charleston*, *San Francisco* and *Olympia*; the gunboats *Marietta* and *Wheeling*, the monitor *Monterey*, the torpedo boat destroyer *Farragut*, and the battleship *Oregon*. They have also recently finished and turned over to the Japanese Government the fast cruiser *Chitose*, the first contract for a warship made with a foreign power.

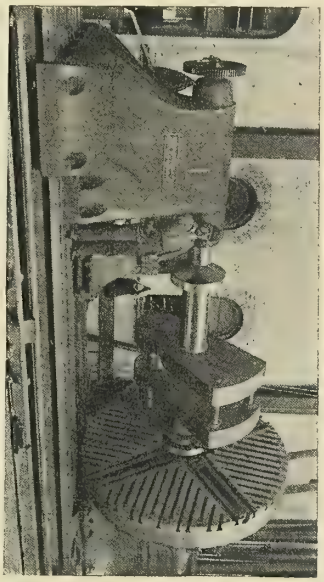
At present they are building the battleships *Wisconsin* and *Ohio*, the monitor *Wyoming*, and the torpedo boat destroyers *Preble*, *Perry*, and *Paul Jones*, all for the United States Government. Work is progressing on a large steel paddle wheel ferryboat for the Atchison, Topeka and Santa Fe R.R., for service on San Francisco Bay, and also on the large freight and passenger steamer *Californian* for the American-Hawaiian Steamship Company, which was described in our August issue. (1899.)

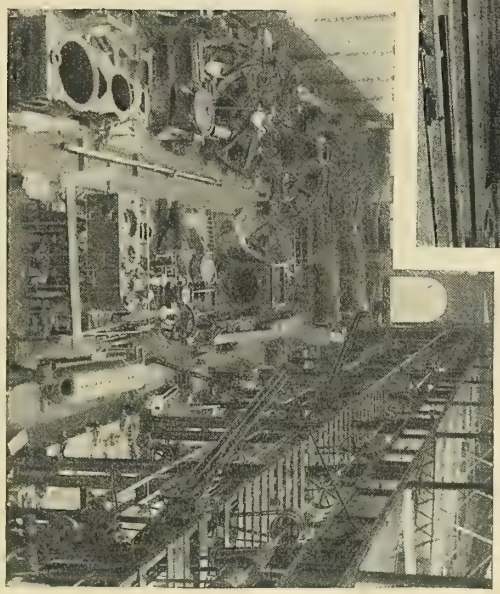
The officers of the company are: President, H. T. Scott; Vice-President, I. M. Scott; Secretary, J. O. B. Gunn; Manager, G. W. Dickie. To the Superintendent, John Scott, and the Assistant Manager, I. M. Scott, Jr., we are indebted for much information and the accompanying photographs.

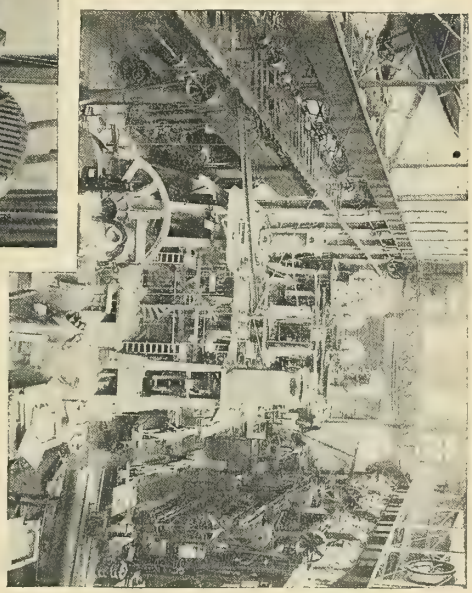
U. S. S. Constitution.—The *Constitution*, more familiarly known as *"Old Ironsides,"* is at the Boston Navy Yard, housed over and used as a training ship. She was built in Boston more than 100 years ago, and took part in many memorable engagements, including the attack on Tripoli under Admiral Decatur, where she was his flag ship; and under Captain Isaac Hull she gained the famous victory over the *Guerriere* in 1812. Her dimensions are: Length between perpendiculars, 175 ft.; beam, 45 ft.; mean draft, 20 ft.; displacement, 2,200 tons. The movement which has for its object the refitting of the old *Constitution* deserves widespread support.

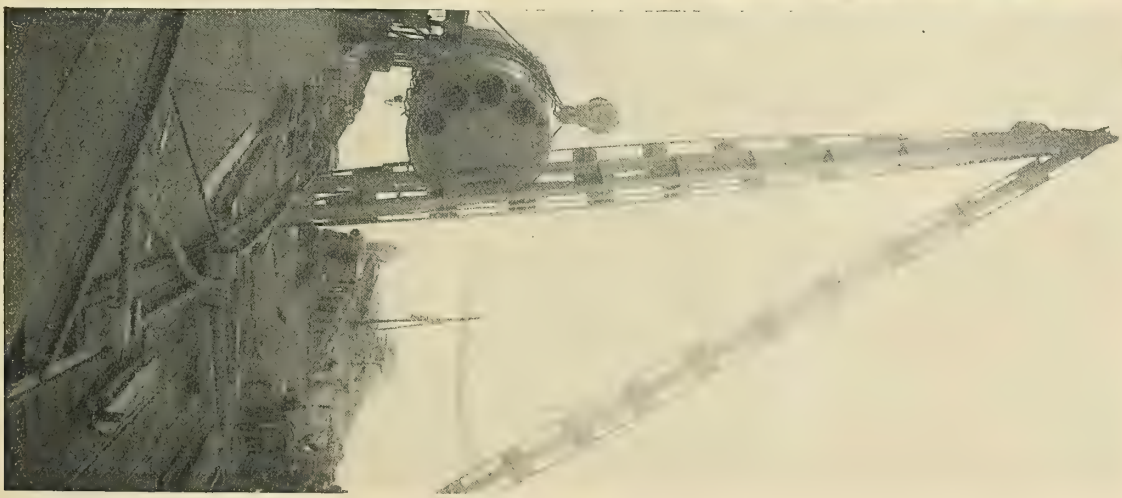












PHOTOGRAPHIC VIEWS OF THE INTERIORS OF SHOPS, SPECIAL TOOLS AND 100 TON SHEARS, AT SHIPYARD OF UNION IRON WORKS, SAN FRANCISCO, CAL.

SUGGESTIONS AS TO IMPROVED APPLIANCES FOR LAUNCHING SHIPS' BOATS.*

BY JOHN HYSLOP.

It is a characteristic of the present time, which forces itself upon the attention and into the recognition of the least observed, that there is a restless and ceaseless activity to meet in every variety of form and method all the numberless wants and demands that society feels, and to which any expression is given; and the exercise of industry, ingenuity, and invention to this end has become so common and has been so successful that the most marvelous productions are simply in line with expectancy, and scarcely any longer excite wonder or admiration. While this state of matters obtains in regard to things generally, and while the devices and methods of fifty years ago have been, like the flint-lock gun and the stage coach, put away to make room for more modern and superior contrivances, it yet remains that the vast development of ocean travel in the past half century and the increased water traffic of every kind has been unattended, excepting in rare instances, with any change whatever in the method of launching ships' boats, and with only here and there such changes in detail as leave the vital requisites yet to be found, recognized and put into use. Such a state of things is in these times an anomaly, and confronts us with the question: Why should this be so? This is much more easily asked than correctly and satisfactorily answered, and in a measure the solution of it must be left to the unaided consideration and conviction of each individual. It is, however, impossible to believe that the difficulty lies wholly in the lack, with proper inducements, of ability in contrivance.

It is equally clear that any progress in this matter, any effort to introduce improvements, to be successful must be well-devised and practically adapted to conditions, and must be aided by an aroused public feeling. One cause, doubtless, why more has not been done in the attempt to improve has been in the lack of technical knowledge on the part of those with whom has rested the adoption of new propositions, and a consequent want of confidence in any estimate they might make of the value of such propositions, or of the possibility of effecting any amendment. Another cause has probably been that, in the very nature of the case, marine disasters are removed from public observation, and impressions in regard to them usually come from survivors; and these in the worst cases are few, or perhaps none. Abundant proof has been had from time to time of the power of a ship's boat, successfully launched and well handled, to survive the storm in which the vessel herself foundered; yet how many are the cases which will come to memory of any who may choose to recall them of vessels that have left port never to be again heard of. The writer has no wish to be an alarmist, but in this matter to be forewarned should assure that we be forearmed. We all know the suddenness with which disasters may occur to any vessel, some of them of a character such as no human care or foresight can foresee and no human skill can prevent, and to meet these no means of launching boats other than the most prompt and reliable can be of any avail whatever. It is not alone that a ship may strike off a rocky coast on a dark night and be under water in ten or fifteen minutes through faulty and unchecked navigation; such occurrences can be rendered far from likely by better methods and checks which, I am happy to know, have been introduced on some of the best steamship lines; but who shall say that any means yet devised will prevent the possibility of collision with an iceberg or a derelict on a dark night or in a fog?

In case of such an event it is not to indulge in mere hypothesis or speculation to say that, with a vessel proceeding at any ordinary speed nothing but the most speedy launching of boats would be effectual to save a single life. To say this is not to speculate, but to state the result which might reasonably be expected. In this respect to have had boats afloat in five minutes would, no doubt, in disasters of the past have been the means of saving countless hundreds of human lives, where an inability to do this in fifteen minutes, or even ten, has meant blank failure and a calamitous end to faithful and heroic efforts, which in many cases may have left no record and only blank mystery. If any apology is needed for presenting a subject in this way to a society which, perhaps, in mere ordinary course is accustomed to give its attention exclusively to matters of economy and mechanics, it may be accepted as sufficient that the writer regards the Society as more capable than any other of dealing instructively and effectively with the question; and he hopes, by impressing upon the Society the need of improvements, to enlist its aid to the effecting of them. He has greater expectation from this, and from remarks and suggestions which may be made as the result of reading this paper, than he has from any original devices or suggestions that he may be able to present. As a further excuse for dwelling somewhat on the need of improvements, and of greater attention to the subject of launching ships' boats, the writer feels impelled to state that he has stood four different times on ships' decks when it has been necessary to launch boats to save life, and on none of them was this quickly and effectively carried out. On the last and most disastrous of these occasions it was most distressing to see 150 men, women, and children waiting through ten to fifteen minutes, each elapsed minute narrowing the limit of life to over two-thirds of that number, only one boat being got clear of the ship, and that one in a damaged condition, through efforts faithful, persistent, strenuous, efforts attended in some instances with serious injury to workers, which ceased only when workers and passengers were submerged.

The question has no doubt occurred ere this to the mind of many of those I am addressing: "Wherein is the difficulty?" And some of these may say: "I have seen boats put afloat from a ship's deck within three minutes from the time when the order was given." This is quite true where all conditions are favorable—where it is daylight and everything is in plain view, where the ship is neither rolling nor listed to starboard or port, where, perhaps, only one boat has to be launched, and this one handled exclusively by sailors; but the impression gained by any such experience is apt to be misleading, and it has, I feel assured, misled many who have an interest in such matters.

A better conception of this state of things may be had if I should refer to an examination of the appliances

*Read at the seventh general meeting of the Society of Naval Architects and Marine Engineers held in New York.

for launching on one of the largest transatlantic steamships recently made, in the company of one of the ship's officers. The davits were of the ordinary kind, turning in sockets on the ship's sides, and with the heads usually turned inboard and over the boats, resting in chocks upon the vessel's upper deck many of the details connected with launching were excellent, and I shall have hereafter to refer to and recommend some of them.

The boats were large and heavy, but it was easy to credit the claim made that on occasions one of these had been put into the water in two and a half minutes. When, however, the question was asked, "What could you do if the vessel was rolling or listed?" the answer was, "We know we could not launch them at all." This answer has since been confirmed by other practical and intelligent officers to whom it has been put. The chief difficulty appears to be this, that while it is comparatively easy to turn heavy davits and to move boats in the direction of a horizontal plane, and while such davits and boats will stay out, and the davits can be stayed by the ordinary guys in the inboard or outboard position when the ship is upright in quiet water, neither movement is practicable when the vessel is rolling or pitching in a seaway, or when she is listed to port or starboard. On the contrary, as I know from experience and actual occurrence, attempts to get the boats over the side at such times are liable to be attended with the loss of life or limb, or by other injury; and the most strenuous efforts made and long continued are apt to be wholly abortive. The crudity and inadequacy of these contrivances would seem to be obvious to any one whose attention is called to them, and indeed the certainty of difficulty, if not defeat, under any but the most favorable conditions.

Where it is expected that heavy boats will have to be used with any frequency at sea it is, I think, safe to say that no such means of launching them would be relied on. It would be regarded as a novelty to see a whale ship fitted with davits of this kind. While it is not to be expected that Atlantic liners shall be fitted with whale ship's davits, it appears both interesting and instructive to inquire how far it is practicable to carry ship's boats inside the lines of a ship's side and yet at all times outside the davits; and also to inquire if any better means can be used to operate and control the present common form of davit. Before doing this it may be well to mention the chief details of work necessary in launching: Removal of the canvas covering, casting off the gripes, throwing down the outer chock (if this be so arranged), casting off the lanyards or tackles of the guys, hoisting the boat clear of its seat, pushing outward the boat and davits and securing the guys, lowering away evenly the boat by the falls, and unhooking the falls and pushing clear of the ship. Every one of these processes is important, and many of them in instances have been improved. In the search for new forms of davits it is questionable if the same identical form will be found equally applicable in all cases; and even if the same form is found to be generally applicable, some modification of detail will be necessary. To my mind the principle of the Mallory davit, patented 1871 and 1873, has much to recommend it; it is simple, and vastly superior to the common form.

It is inexpensive, but not bulky; has no need of guys. The boat, though kept inboard, is always outside the davits, and gravity alone will carry the boat outward ready for lowering when the ship is on an even keel or only moderately listed; and when more extremely listed, any force used to overcome this is more easily and much more effectively applied. The accompanying illustrations, Figs. 1 and 2, will make the construction and the mode of operation sufficiently clear. A frame made of stout angle-iron is extended outward from the top of a house or boat deck, across the width of the gangway of the deck below, and then vertically to that deck, where it terminates and is secured inside the rail; the horizontal part and a small portion of the vertical part of this frame is made double, with a separation and a space of approximately 2 in. between the two members of the frame. Hinged near to the house on the lower deck, on a level with the foot of the frame and separated from it by the width of the gangway, is the davit; this extends upward from the hinge to and beyond the inboard side of the boat, over which the head is bent in the usual manner.

When the boat has to be launched it is raised by the falls from its seat, the chocks thrown down and the boat allowed to move outward by means of the fall attached to the back of each davit, and to a distance sufficient for the boat, when lowered in the ordinary or in any other way, to be clear of the ship. This form of davit does

FIG. 1.

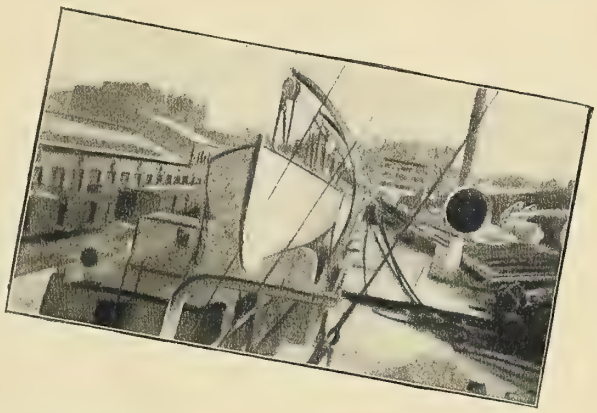


FIG. 2.

VIEWS OF MALLORY DAVIT.

not appear to have been adopted or known to the extent that might have been expected. It is a strong and a light device, the strain upon it being only in one direction, and there being no occasion to make it circular in cross-section, being made from flat bar iron. Those I have seen on the newer vessels of the Old Dominion Line (used for boats not of the heaviest kind) being about 5 in. by 1 1-4 in. in cross-section. There is no

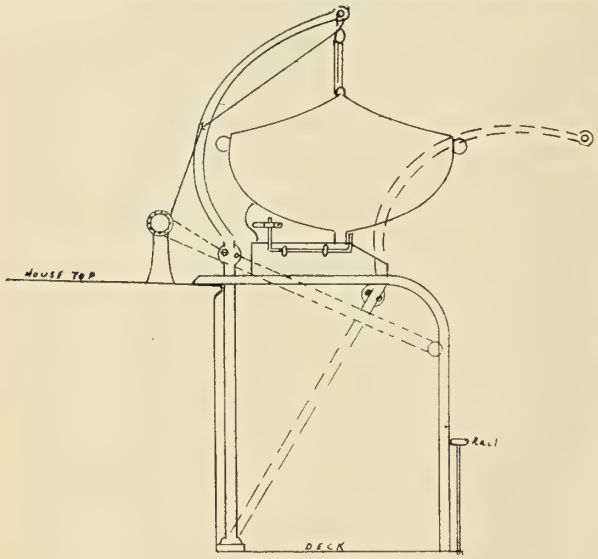


FIG. 3.

uncertainty, in my view, as to the advantages of this davit, and none as to the differences in result which might have been attained to had this method of working been in use where it was my painful experience to see others fail.

It is, however, I think, susceptible of adaptations that have not yet been made, and is too open to the criticism that the means to operate it under favorable and also unfavorable conditions are not present, are not all of them fixtures, and always ready for use. The fact that two tackles, one to each davit, have to be stretched across the deck, then seen to be clear, and hooked on before the davits are operated, is an objection; and although, in case of rolling or of extreme list, these davits would be much easier to control than the ordinary ones, this is not enough. To fitly meet such occasions as arise, appliances should be such as by reliable and simple means, not to be defeated by rolling or listing, requiring only manual power, and few men, and controllable throughout the process, the boat must be moved out to a position ready for lowering. The operative means to effect this should be a reasonably compact and unobtrusive fixture, always ready for use. Reference to Figs. 1 and 2 will show how easily could be arranged in connection with them a small shaft upon the upper deck, running in line with the boat and just inside the davits; this shaft could be supported at each end by a compact frame or standard, have winch handles on, and a sprocket wheel near to each end; over this wheel would pass a chain which would also pass over a pulley upon the outer part of the davit frame. The ends of the chain would be connected with the davit on opposite sides in such a way that the revolution of the sprocket wheel by handles would move the davits either outward or inward, or hold them at any point desired.—Fig. 3.

It will be seen how a turn with the bight of the boat falls, over a small drum placed on the shaft, would at the same time carry out the davits and raise the boat from its seat. In such ships as have a shelter deck extending over the width of the gangway of the deck below, davits of the form shown could not be used without the shelter deck, on which the boats rest, having slots cut in them for the movement of the davits outward and inward. The extent of such slots could, doubtless, be much reduced in such cases by modifying the form and curvature of the davits, and, if need be, by also changing somewhat the detail of the method used for operating them, and this without any departure from the general character of the means used. It does not appear evident, however, that any insuperable difficulty or objection can apply, on account of weakening or impairment of the shelter deck through the presence of such slots, which could be supplied with proper curbs, and which openings the chock would ordinarily cover. The writer will not pretend to deal exhaustively with this, or, indeed, with any other part of this subject, with the mechanical parts of which he feels that many of the capable minds of this Society can deal more effectively than he can.

Any reference to the class of davits which fall outward from the sides of a vessel would be very incomplete which should omit the ingenious and well-worked-out device of Sir Bradford Leslie, of Falmouth, Eng-

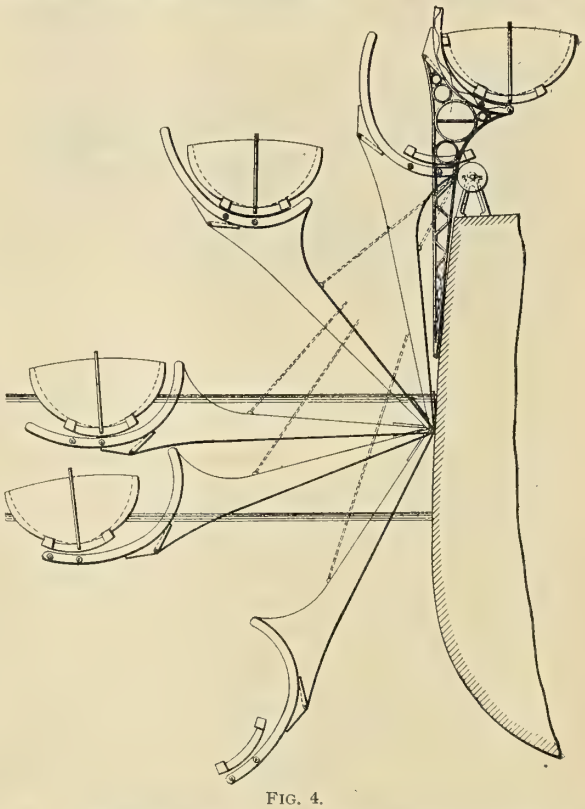


FIG. 4.

land. Sir Bradford is a retired engineer of much experience in the East Indies.

His life was placed in jeopardy by shipwreck some years ago, and he has shown that he possesses the requisite technical skill to deal with the detail of his invention in a very thorough manner. For an intimate acquaintance with it I must refer you to the U. S. pat-

ent, May 4, 1897, number 582,069. (See Fig. 4, reproduced from the patent.) The chief novelties of his method are that there are no boat falls, no lowering or hoisting tackles attached to the boats—these are supported from below on cradles situated on the heads of the davits. The davits themselves are lowered vertically in slides down the outside of the ship through a space of a few feet; having passed downward through this space the heads of both davits, with the boats resting upon them, fall evenly outward and downward until the boat is deposited on the water at an oar's length or more away from the ship, the davits being allowed to sink a sufficient distance free of the boat. This lowering apparatus consists of a wire rope wound round a drum on the ship's deck, and fitted with a suitable brake. A full description of this contrivance would fill the limits of this paper, and would occupy more time and space than is available.

In regard to the invention, I think it will be conceded that it possesses great originality and thoroughness—that it attains to many desirable ends. If it is thought to be too elaborate or too costly to meet with practical acceptance it will still, I trust, be deemed a sufficient reason for a reference to it in this paper that its methods are novel and calculated to afford a variety of useful suggestion. While the author of this ingenious invention may feel justly proud of it, my short acquaintance with him has given me a strong impression that he would feel nothing but gratification in having in any way promoted the successful achievement of the end he had in view.

It appears doubtful if any simple and reliable means can be devised for getting boats ready to lower where the davits have to be rotated, and where the boats have to be moved from a position inside the davits to one outside of them, and this operation, so easy when the deck is level and still, becomes one of extreme difficulty when the vessel is rolling, or when she is inclined; ordinarily the work involves time and effort which ought to be eliminated. The use of a cog-wheel secured to the vertical part of the davit, say immediately over the rail of the vessel, the cogs of which wheel engage with a worm attached to a shaft running horizontally across the rail of the vessel, the shaft being turned by a handle situated on the periphery of a wheel placed on the inner end of the shaft, seems calculated to give a control over the whole range of the davit's movement not to be had in the ordinary way. The vessel on which I recently crossed the Atlantic had two of her boats fitted with davits operated in this way, and it seems strange that so simple a device is not in more common use.

The patent of James W. McKinnon, March 16, 1897, No. 579,119, has this appliance as one of its features, and has otherwise many ingenious contrivances for raising the boat clear of the chocks, and for the even and steady lowering of it, either from the deck of the vessel or from the boat itself; but I regret that I am not sufficiently familiar with the details of it to attempt a description, and copies of the patent papers do not, as I understand, show the latest form of the invention.

In discussing this subject I have hitherto occupied myself chiefly with the means for operating the davits themselves, and there is with me no doubt that here, more than anywhere else, is there a confessed need of improvement. I have spoken with many ships' officers, but have yet to meet with one who will say that, with the ordinary appliances, a ship's boat could readily be launched under conditions of practical difficulty such as have been alluded to. But, while the kind of davits and the mode of operating them is of first importance, every detail and process of launching ships' boats is important, and deserving of more attention than it appears to be receiving. Differences in equipment of vessels, often in regard to simple details which scarcely involve the matter of expense, and which do materially affect efficiency in working, suggest as explanation either a want of interest or a need of information, or even, more probably, the need of an institution or of a body of men who, duly qualified, could, more than any individual, be confidently relied upon to acquaint themselves with these somewhat technical matters, to digest the information received, and to make such statements or recommendations as should appear to be called for in the interests of humanity. With a large measure of authority would come from such a body a pronouncement in regard to any davit device observed; also in relation to the respective merits of iron and wooden boats; to the advantages of cork fenders carried in the form of bolsters around a boat and below the gunwale. Chocks and releasing tackle would receive attention, gripes and davit guys would also be commented on, and probably for the guys, if these must continue to be used at all, tackles instead of lanyards would be recommended.

The differing situation of boats about vessels' decks is deserving of consideration—some on chocks near to the deck level, and needing to be hoisted several feet to pass over a rail; some kept at rail height, and too high for passengers to get into them; some overhead and inaccessible until lowered outside the rail; and some, like the boats of the *Kaiser Wilhelm der Grosse*, placed upon and close to the upper deck, having no rail either inside or outside of them, themselves constituting a bulwark, and ready to be launched with all the facility attainable where the ordinary davit is in use. Where the simplification of every process means so much, attention may here be called to the double use of the cork bolster put round the lifeboats of the vessel mentioned; this is not only a protection to the boat in case of collision with the vessel or otherwise, but it affords an admirable means for securing and for instantly detaching the canvas cover which ordinarily is fastened over the boat when it is upon the deck.

This cover extends over the sides and down beyond the bolster, and has a loose lacing of small rope rove through grommets upon the edges, a line passing through the lacing along each side the boat is tightened up and the ends toggled together at stem and stern, the effect being to gather the edges of the cover inward under the bolster and to secure it, and again to instantly release and free it when this is desired by slipping the toggle.

The cover in this way is removed intact in very much less time than it could be cut adrift by a sharp knife. Of the various means in use of throwing down the chocks on which the boat rests, or at least of removing the outer ones so that it can be launched, those on the *Kaiser Wilhelm der Grosse* seem adequate, and nothing

could be more simple. Any pressure from wind or from a sea shipped would be from the weather side, and would bear inward. On the inner side the boat is supported by the two chocks in the customary manner, and is held in firm contact with it by the gripes. It is held from moving outward by an iron rod, carried from inboard outward and horizontally through eye bolts on the face of the lower part—the stationary part—of the chock; this rod is turned up at a right angle for a few inches at the outer end in such a way as, when operated from the deck at the inner end, where a lever handle is situated, the outer end is turned up outside the keel and the boat's movement is prevented.

The matter of releasing gear is too important to wholly omit mention of in a consideration of this subject; there can, I think, be little doubt that in rough water, with ship and boat in active movement, the handling of boat falls and hooks is attended with both difficulty and danger, even in daylight—it is, of course, even worse in darkness—whether this be done for the purpose of letting go or of hooking on. It is important that the two ends of the boat be lowered evenly, and that the falls be so rove through the blocks that if one end be let go the other, either by getting foul or being held on to, may not prevent both ends of the boat descending to the water and becoming water-borne. There are many devices for detaching the lower hooks; not all, perhaps equally free from the risk of fouling, or sure of smooth and reliable working. It might be invidious to select one for preference, unless, indeed, from a more intimate acquaintance with the history of its working than I can claim; the U. S. Government and many merchant vessels have however, I understand, made considerable use of one of these which appears to me to be a good contrivance, and is well deserving of attention. I will only say in conclusion that whatever appliances are used should be kept in good working order. If wooden boats are used these should not be dried out and leaky, so that they cannot be kept afloat, as has too frequently happened; boat falls should be of good, pliable rope that will run easily and freely through the blocks without choking and without kinking; and for the rest, if the present means for launching boats in times of difficulty and disaster are not improved upon, and if it should ever again be my misfortune to have a ship go down under me, I hope the temperature and distance may admit my swimming ashore, as otherwise I would rather put my trust in a spar, hatch, or plank, or in anything that might float, than in the likelihood of getting boats properly afloat in any short period of time. I trust that I may here be permitted to suggest that the appointment of a committee from the members of this association to thoroughly investigate and consider this subject would give promise of results such as would be eminently beneficent, worthy of the effort made, and of the Society, and not so well attainable by any other means in sight.

Various exaggerated statements have appeared in the daily press abroad and here regarding the speed attained by the turbine driven destroyer *Viper* on her preliminary trials. It appears to be the fact that no extraordinary speed was reached and that the trials were simply for the purpose of getting the machinery in condition for the full speed run.

OFFICIAL SPEED TRIALS OF THE 30-KNOT U. S. TORPEDO BOAT DAHLGREN.

Probably no vessels built in recent years for the United States Navy have been viewed with such interest by engineers as the torpedo boats *Dahlgren* and *T. A. M. Craven*, built at Bath, Maine. In our issue of September, 1899, we published extensive details of these vessels, especially of the machinery, which in many respects is radically different from the designs most frequently met with. In the engines, notably, photographic views of which we published at the time, the difference of model is very apparent. Instead of comparatively high engines consisting, in effect, of a slender steel framework with a row of cylinders on top and crank shaft and bearings at bottom, there is shown a very compact machine—a concentration of power, as it were. Instead of the familiar turned steel columns there is a framework of manganese bronze, securely bolted to the steel bed plate. The practical value of this form of engine was demonstrated in the recent severe trials of the *Dahlgren*, which were carried out without hitch or slow-down for any defect or derangement of machinery. These trials we here propose to describe. It will be recalled that the *Dahlgren* is of the Normand type, with modifications of design introduced by the builders.

On October 23, at 1.05 o'clock in the afternoon, the *Dahlgren* left the yard of the Bath Iron Works, Bath, Me., for the first part of her official speed test. The vessel was deeply laden, and all the prescribed weights were on board, plus coal and water sufficient to take her to the measured mile off Southport, Me., and also to furnish steam during all the low power runs. The trial board, the builders' staff, and the officers and crew were all carefully weighed as they stepped on board—there were 34 men all told on each of her trial runs. The hull and machinery of the vessel were completed, with the exception of linoleum on deck and the canvas ceiling in the living spaces, and this weight was allowed for. The following are the weights of the *Dahlgren*, together with the trial load specified to be carried on trial:

Hull complete with fittings	44.55	tons.
Machinery complete with steam up	78.20	"
Coal	9.00	"
Crew and effects	2.50	"
Outfit	4.50	"
Ordinance	4.29	"
Total Trial Load	20.29	"
Displacement	143.04	"

The government trial board consisted of Capt. Emory, President; Commander Charles R. Roelker, Engineer; Washington L. Capps, Naval Constructor, and Lieutenant-Commander Henderson, U. S. N. The trials were in charge of Vice-Pres. John S. Hyde of the Bath Iron Works, and the builder's staff included Consulting Engineer Charles E. Hyde, Chief Hull Draughtsman William A. Fairburn, Chief Engine Draughtsman Edward S. Hutchins, and Charles P. Weatherbee.

The *Dahlgren's* official trial consisted of a standardized screw test, which occupied a part of three separate days. On Monday, October 23, the programme called for a progressive trial on the measured mile off Southport, Me., so that the relation between the revolutions of the screw and the speed of the vessel could be accurately determined when the vessel was carrying the full specified trial load. On this day Fort Popham was reached at 1.45 p m., and at 2.08 p. m. the *Dahlgren* was off the

"Cucholds," she having steamed easily under natural draft at a 17 knot rate. At 2.45 p. m. the *Dahlgren* steamed over the Southport course towards Boothbay, due north, on the first run of the progressive test. In slack water she covered the mile in 2 min. and 47.6 sec., which is equivalent to a rate of speed of 21.48 knots. The mean revolutions per minute were 234 for the two engines. The vessel then made a long loop turn without reducing the speed, and returning she covered the mile in 2 min. 40.25 sec. (which is equivalent to a speed rate of 22.46 knots) with 243 turns per minute. The third run on the mile and the first of the second series gave a mean speed of 24.61 knots, with 265 revolutions. After making a long sweep the *Dahlgren* made the return run in 2 min. 28.5 sec. with 263 revolutions per minute, this time being equal to a speed of 24.24 knots per hour. Run No. 5, which was the third run north, was made in 2 min. 17.4 sec. with 278 revolutions. This performance is equivalent to a rate of speed of 26.20 knots.

The vessel's change of trim was now particularly noticeable. Walking from the quarter deck forward seemed as if one was walking up a steep hill. Flames shot from the stacks, and thick smoke was trailing behind for a distance of at least two miles. There was no disagreeable whipping and racking perceptible, as is frequent on boats of this class. At a speed of 22 knots the vibrations, although slight, were noticeable, but as the speed decreased or increased the vibrations lessened, and at very high speed or at ordinary cruising speed the vibrations were practically nil. After the fifth single run the speed was so great that it was not considered advisable to attempt to turn the vessel at full power, owing to the limited space for manœuvring necessitating great helm angle, and this great angle of the rudder always causes the affected propeller to race. The vessel was therefore slowed down to about 25 knots' speed to make all the turns, which was detrimental to speed with quick-steaming water tube boilers. The sixth run of the progressive trial, which was the third run to the south, resulted in a speed of 27.36 knots with 288 revolutions. the time on the mile being 2 min. 11.6 sec. A long sweep was now made, and the next run north was accomplished in 2 min. 01.6 sec., the speed being 29.61 knots with 313 revolutions. The return run was made in 2 min. 0.7 sec., the speed being practically the same (29.59 knots), and the mean revolutions on the mile 312 per minute.

A fifth double run was about to be made at maximum power, but as it was growing very dark, the builders decided to postpone the full power runs on the mile until the following day. The *Dahlgren*, therefore, was headed for home, having successfully passed through the first stage of her official trial in splendid fashion. She reached Bath about 7 o'clock in the evening, having covered the 21 miles in about 1 hour under cruising conditions with natural draft.

The following day, October 24, the vessel left Bath at noon with the same personnel on board, for the measured base at Southport, to complete the progressive trials and to continue the turning and manœuvring tests. The trials were not quite as interesting as those of the previous day, but greater speed was shown and the vessel dashed over the mile in just 2 min., the counters showing 317 revolutions. Several runs were

U. S. TORPEDO BOAT DAHLGREN TRAVELING AT A HIGH RATE OF SPEED NEAR BATH, ME.

made at rates of speed varying from 30 upwards, and a run at 27 knots checked the data taken the previous day. The vessel behaved splendidly. At top speed she seemed to make much less fuss cutting through the water than she did at 26 to 27 knots. The forefoot lifted almost out of water, and the origin of the bow diverging wave seemed to be near the forward conning tower. No flames could be seen shooting from the stack, but the vessel went forward at railroad speed. The speed on all the vessel's measured runs was increasing all the time she was on the mile, showing that the remarkable speed attained was no "bottled up" spurt performance.

The vessel was given two ten-minute runs in the open sea as a preliminary canter for the one-hour's sea run that was to follow. The first 10 min. gave a mean speed of 30.4 knots, and the second 10 min. trial resulted in a mean speed of 30.6 knots. As the afternoon was now well advanced, the builders decided to return to Bath, where they arrived about dusk.

The trial board were summoned to the Charleston Navy Yard Tuesday night to inspect the training vessel *Chesepeake* in dry dock, so it was not until Friday, Oct. 27, that the official trial of the *Dahlgren* could be concluded. In the meantime the wind had been kicking up a nasty sea, but as the prospects were not good for fair weather in the near future, the builders decided to risk running her for an hour or more in the open sea under what would be considered, for this class of boat, very unfavorable conditions. In that region towards the end of October continued good weather cannot be expected, and as the fall and winter advance the sea get less and less suitable for high speed runs with small, light boats. The builders had either to run the vessel on her trial and make the 30 knots in an hour as required, or else pay a heavy penalty for delay in completing the vessel, and of the two evils they considered the former the lesser. The *Dahlgren* accordingly left Bath at 7.30 o'clock on the morning of Oct. 27. She arrived two miles beyond Seguin an hour later, and at 9 o'clock she was headed southwest for the Isle of Shoals. The board was notified that all was in readiness for the official speed test.

The vessel did not respond to the order of full speed ahead as rapidly as she usually does in smooth water. The machinery had to be "limbered up" somewhat, and, therefore, the first observation taken gave the vessel a speed of only 27.5 knots. In a nasty quartering sea that caused the little vessel to roll badly and throw water all over herself she gradually increased her speed. After running fifteen minutes the observations showed that she was traveling at a 29.5-knot gait. The flat knuckle stern and the high speed of the boat kept the wheels from racing, but the sea and wind were a great handicap. Gradually the speed increased, and after traveling about one-half hour the speed had risen to 30 knots. The sea was growing worse all the time, but the boat's complement worked without remission. On two occasions the speed reached 30.8 knots, and the best time was being made when the orders were given to slow down. The vessel had steamed at full power for about 100 min. The mean rate of speed attained was 30.05 knots, a really wonderful performance for a small high-speed boat in a rough sea.

After successfully passing through severe turning and steering gear trials the *Dahlgren* put into Portsmouth, N. H., where she remained until Sunday, Oct. 29, when the weather had moderated sufficiently to warrant making the return trip to Bath. All on board were enthusiastic over the performance of the little vessel, for she passed through the severest tests without a flaw being discovered. On her first attempt at an official trial she proved successful, and although greatly handicapped by most unfavorable conditions of wind and sea, she slightly exceeded her designed speed of 30 knots.

There has never been any breakdown or accident aboard the vessel, and the hull and machinery have stood the stresses of preliminary runs and official tests without exhibiting any defects. A speed of 30 knots in a heavy sea on a displacement of 140 tons, 15 per cent of which is trial load, is a remarkable performance; but when it is remembered that this speed was obtained with a piston speed of only 1,100 ft. per min., and less than 320 revolutions, and moreover that 4,200 I. H. P. were gotten out of two boilers, the results seem almost beyond present possibilities. Yet they are official and undisputed.

U. S. STANDARD LIFEBOAT PROPELLED BY GASOLENE ENGINE—SEE PAGE 22.

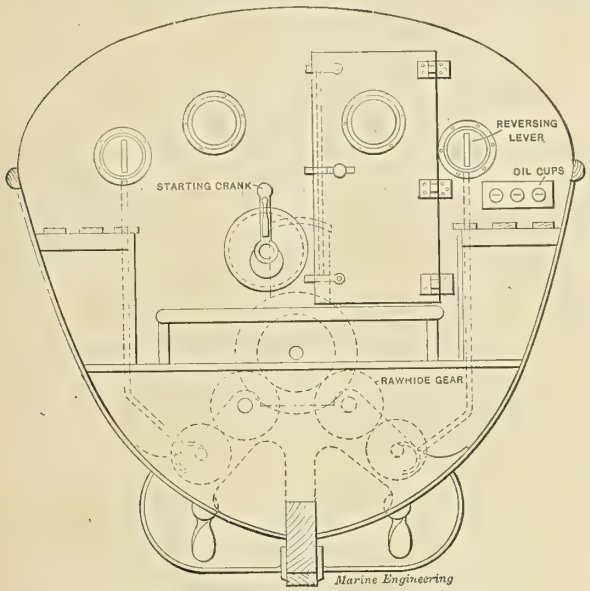
S. S. PENNSYLVANIA.—The freight and passenger steamship *Pennsylvania,* of the New York, Philadelphia and Norfolk Railroad, was launched from Roach's yard, Chester, Pa., December 16. This vessel is of the following dimensions: Length, 260 ft.; beam, 40 ft.; draft, 9 ft. 9 in. She is very fully powered, and is expected to attain a high rate of speed for a vessel of this class. She will run between Cape Charles, Old Point Comfort and Norfolk.

TWIN SCREW LIFEBOAT FOR THE U. S. LIFE SAVING SERVICE.

BY LT. C. H. MCLELLAN, R. C. S. ASST. INSPECTOR.

There are two principal classes of boats used in the United States Life-Saving Service, the lifeboat and the surfboat. The lifeboat, because of its great weight, 6,000 to 10,000 lb., is located where it can be launched into comparatively smooth water from a cradle, as in the harbors of the Great Lakes, and is propelled by oars and sails, or assisted by a tug boat to the vicinity of the wreck. The surfboat, weighing from 1,200 to 1,500 lb., is placed at all of the coast stations, and is easily transported along the coast on specially constructed carriages to a point nearest the wreck, and then launched from the beach. The surfboat is also supplied to all of the Lake stations. The lifeboat is propelled by ten oars, pulled double bank, and three sails. The sail plan is small and heavy, as it is mostly used in heavy winds.

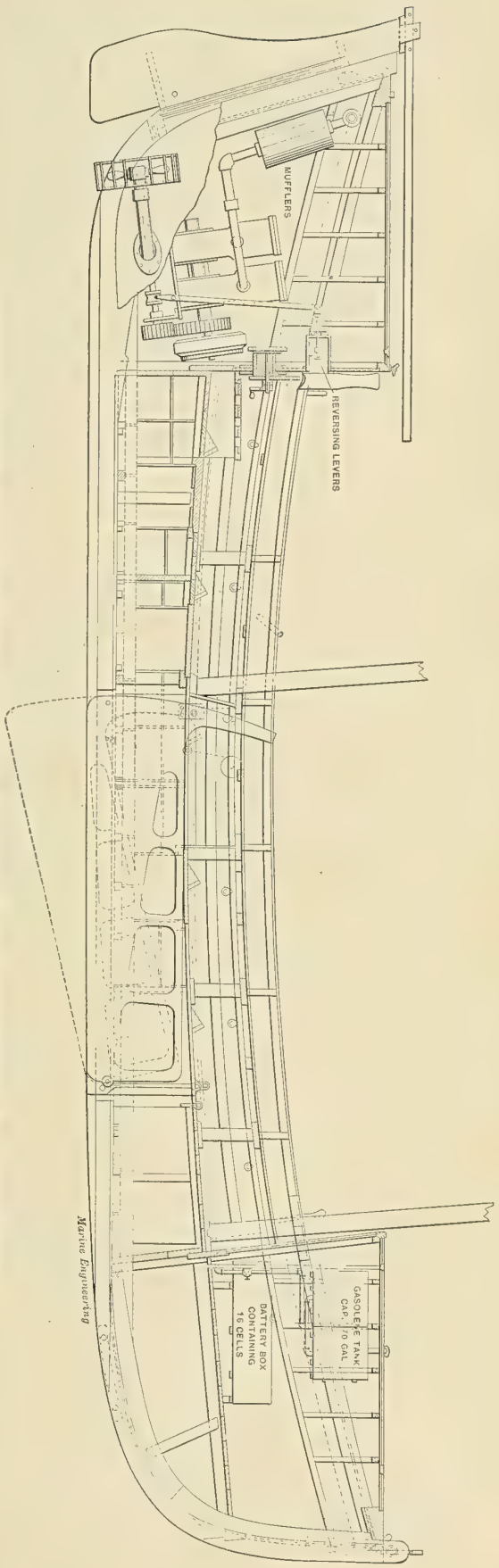
If the vessel in distress is a considerable distance from the lifeboat station the assistance of a sea-going



ENLARGED SECTION AT AFTER BULKHEAD.

tug is usually necessary to tow the lifeboat to the vicinity of the wreck, when the tow line is dropped, and the lifeboat manœuvred to get within reach of the wreck and make the rescue. Usually, if the conditions will permit, the lifeboat is dropped to windward and pulls down to the wreck and takes off the crew, and in the meantime the tug has steamed to leeward of the wreck, where the lifeboat joins her after the rescue. This process is necessary because of the great weight of the lifeboat and the difficulty in pulling her against a wind of any force. It consumes much time, which is augmented in many cases by waiting for the tow boat to get up steam, or from there being no tug immediately available.

The necessity for a lifeboat with power has long been recognized, both in this country and in Europe, but because of the peculiar work required of the lifeboat the problem has been difficult of solution. The British Royal Lifeboat Institution has been working on this problem for several years, with doubtful success, having built



LONGITUDINAL SECTION OF U. S. STANDARD 34-FT. LIFEBOAT, PROPELLED BY TWIN SCREWS DRIVEN BY GASOLENE ENGINE.

several steam lifeboats;* but in the opinion of many the mistake has been made of building their boats too large, they being, in fact, seagoing tugs. The lifeboats of the U. S. Service are made self-righting, as they are used in surf which can, and frequently has, capsized them. A boat with steam power, if capsized and rolled completely over, would have but little assistance from its engine afterwards. Experiments have recently been made by the U. S. Life-Saving Service with a gas engine as the motive power, and with very gratifying results. The Service 34-ft. lifeboat was selected, the largest class in use, and in this a 12 H. P. "Superior" gas engine was placed. This engine was selected because of its lightness per horse power, simplicity of construction, compactness, and its ability to run under adverse conditions. It is also arranged to turn two propellers with one engine.

The engine, with the gears and attachments of the two propeller shafts, is installed wholly within the after air chamber, the only portion of the machine on the outside being the two reversing levers, the end of the starting shaft, and the oil cups. The parts outside of the air chamber are in recesses in the bulkhead, out of the reach of ropes or other dangers, as shown in the accompanying drawing. The engine was installed without disturbing the construction of the boat. It was passed through an opening 16 in. by 16 in., and set up on the inside. The air chamber is 6 ft. long and 6 ft. wide at the gunwale of the boat, tapering to a few inches at the keelson and stern post. The engine weighs 1,350 pounds, is of the two-cylinder type, having an explosion every revolution, the spark being produced by sixteen portable rubber cell batteries. The engine cylinders are 6 in. by 6 in., and the speed of revolution is 400 turns a minute.

There are two 18 in. propellers, having two reversible blades each, the reversing levers being connected to pulls leading through stuffing boxes in the bulkhead. The propellers are protected on the outside by suitable cages. The cylinders are lubricated by automatic oil pumps, and all other bearings by cups placed in a recess in the bulkhead, and accessible from the outside.

Air is supplied to the engine through two 2 1-2 in. brass pipes leading from the top of the inside of the air chamber, down the bulkhead, and opening through it 6 in. from the deck. If the boat should be upset these openings will be in the air space under the boat, and out of the reach of the water.

Gasoline is stored in the forward air chamber and as high as the roof will allow, the gasoline being carried to the engine by gravity, dispensing with the pumps and their different parts so apt to become clogged and fail at a critical moment. The tank in the boat under trial has a capacity of 75 gallons, though there is room in the air chamber to carry a much larger tank if necessary. To prevent the fuel from being cut off from the engine by reason of the extreme pitching of the boat, as might occur in a very heavy surf when the stern is on a high sea, a small reservoir is attached to the engine through which the gasoline flows to the engine. The engine consumes 2 gallons of gasoline an hour when under the full speed of 7 1-2 miles per hour, at an expense of about two cents an hour per horse power.

The batteries are sealed, and carried in a drawer fitting into a close case in the forward air chamber, having its only opening in the bulkhead. By this arrangement the batteries must be removed from the air chamber for any needed attention, thus removing all danger of accident form a spark caused by ignorant handling of the wires.

Provision has been made for cutting off the supply of fuel from the engine in case of a capsize, thus stopping the engine. This is advisable, for without this precaution, if the lifeboat was upset, and the crew thrown into the water, the boat would right almost instantly, and the engine being in motion, would run away from the crew before they could climb into the boat. Another reason for stopping the engine during an upset is the danger from having the passengers and crew thrown into the water with the two propellers running at a high speed in the vicinity. The self-righting qualities of the lifeboat have not been injured by the addition of the weight of the engine. In the tests made she righted from even trim bottom up to even trim right side up in 3 sec.

In these tests the boat attained a speed of 7 1-2 miles an hour over a measured course. She reversed from full speed ahead and had sternway on in 20 sec. With one propeller going ahead and the other astern, she turned in a circle 50 ft. dia. The boat was tested under sail and power during a gale blowing at the rate of from 28 to 40 miles an hour, as registered at the Weather Bureau. She was taken 5 miles outside of the harbor of Marquette, Mich., and tried under all directions of wind and sea, and behaved as well as could be desired. Under the same conditions of wind, and without the engine, a tugboat's assistance would have been necessary, or several hours consumed in beating the lifeboat out against the wind.

It is the unanimous opinion of the officers of the Service who have witnessed the trials of this boat that the Service would have a very valuable auxiliary by its general adoption.

U. S. S. Bailey.—The torpedo boat destroyer *Bailey* was launched into the Harlem river from the yard of the Gas Engine & Power Co., and Charles L. Seabury & Co., Consolidated, New York city, on December 5. The boat was christened by Miss Florence Beekman Bailey, grand-daughter of the late Rear-Admiral Theodorus Bailey after whom the boat was named. An artistic silver loving cup is to be presented by the family of Rear-Admiral Bailey, upon which a suitable inscription referring to the services of the Rear-Admiral under Admiral Farragut will be engraved. The *Bailey* is one of the three boats authorized by act of Congress of March 3, 1897. She has hitherto been classed as a torpedo boat destroyer, but is now placed in the list of torpedo boats of the Navy. The other two vessels authorized under this act are the *Goldsborough,* building at Portland, Ore., and the *Stringham,* which was launched some time ago at Wilmington, Del. The *Bailey* is of the following dimensions: Length, 205 ft.; beam, 19 ft. 2 in.; mean draft, 6 ft.; displacement, 235 tons. She is fitted with twin screws, driven by triple expansion engines of the builder's design, which are expected to develop 5,600 horse power. Her estimated trial speed is 30 knots. The armament of the boat will consist of two 18-in. Whitehead torpedo tubes and four 6-pounder rapid fire guns.

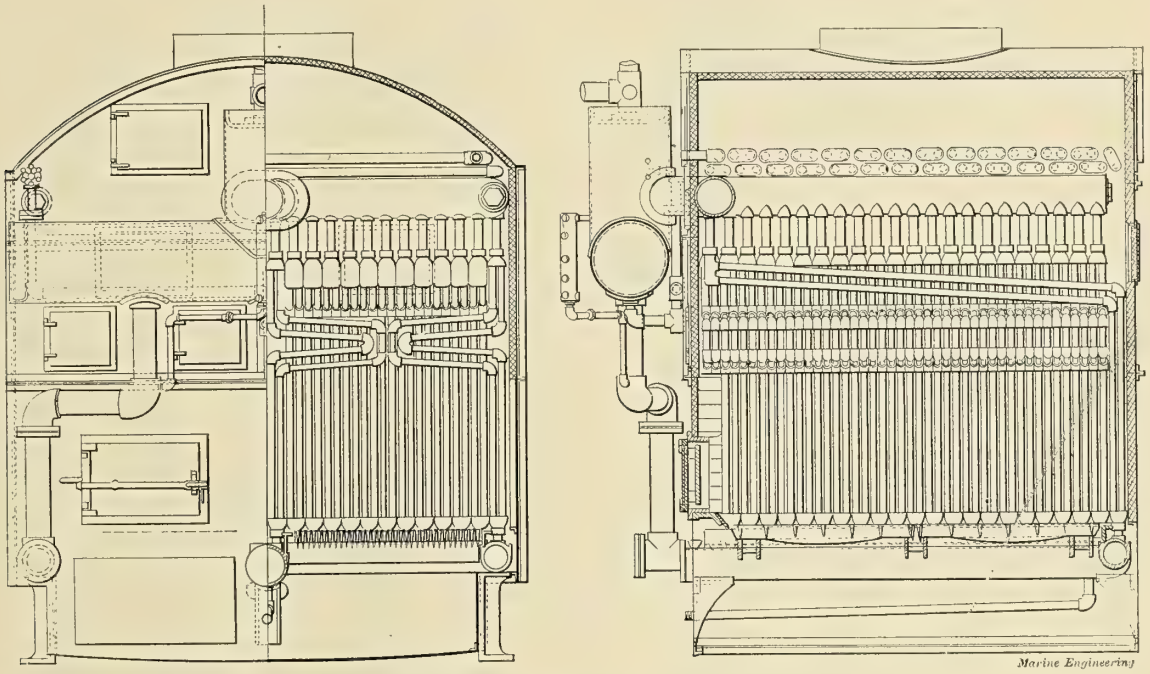
* An illustrated description of a hydraulic propelled lifeboat was published in the issue of January, 1898.—Ed. M. E.

COMMERCIAL TYPES OF WATER TUBE BOILERS BUILT IN AMERICA.—I.

DESCRIPTIONS OF THE ALMY, SEABURY AND NICLAUSSE BOILERS WITH SECTIONAL DRAWINGS.

Almy Water Tube Boiler.

The Almy water tube boiler is composed of a series of straight lengths of tube, both vertical and horizontal, joined together by suitable bends, elbows, etc., with screwed connections. In detail the "single tube" boiler of this type is composed of a continuous manifold at the base, extending along each side and across the back below the grate. At the top of the boiler a similar manifold extends along the sides and across the front and is there connected to the vertical steam dome situated outside the casing. The heating surface is formed by a series of sections composed of tubes connected together by elbow return bends and Y fittings, which are connected to the top and bottom manifolds by unions. The sections at the sides rise straight from the bottom manifold, for a distance, to form the crown of the firebox, and then turn inward, extending half way across the firebox, returning again back to the sides and thence straight up again until they connect with the top manifold. The sections which form the back of the furnace rise from the back bottom manifold to a height sufficient to cross over above and at right angles to those that form the crown of the firebox. On reaching the front they return back again and then to the front again, and are connected to the top manifold, which extends across the front. The several sections form the heating surface. In the double tube boiler the same general design is followed, with the addition that there are two rows of tubes forming the greater portion of the sections of heating surface instead of a single row at the sides and back, as in the single tube type. The feed heater or economiser consists of one or more layers of tubes connected together by screwed return bends, forming one continuous tube, and it is placed over the top manifold. This top manifold is connected with the vertical separator or steam drum fitted in front of the boiler, and this drum is riveted at its lower and open end to the horizontal water reservoir which extends across the front over the fire doors outside the casing. Down flow tubes on each side lead from the reservoir to the bottom manifold. Water circulation is as follows: The feed enters the heater at the top, and after passing through the heater tubes enters the boiler at the bottom of the horizontal water reservoir and flows through the down cast tubes into the lower manifold; thence up through the generating tubes and in the form of steam passes through the top manifold into the separator. There the entrained water is separated and falls into the water reservoir, thus getting into circulation again. The water level is maintained about the middle of the horizontal water reservoir. The blow off is connected in the mud drum which is a part of the lower manifold near the center at the back of the furnace, this being the lowest and quietest place in the boiler. Heating surface ratio of this type varies according to various changes in interior dimensions, number of sections of feed heater and also where two furnaces are employed. In stock sizes, however, it ranges from 25 sq. ft. heating surface to 1 sq. ft. grate surface, to 40 to 1. The tubes are stated by the builders to be of "the best quality of metal," the manifolds and tube connections of air blast malleable iron, and the steam dome and water reservoir of lap welded tube. All Almy boilers are built for a working pressure, of 250 lb. per sq. in. They have been extensively

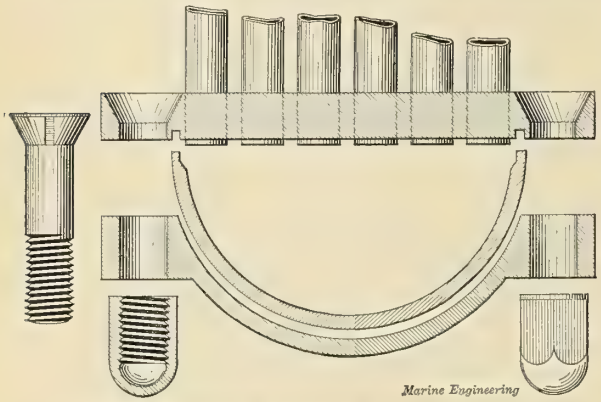


ALMY WATER TUBE BOILER.—FRONT AND SIDE ELEVATIONS.

installed as main and auxiliary boilers in yachts, tugs, ferryboats, steamers, launches and for stationary purposes. The boiler is manufactured and marketed by the Almy Water Tube Boiler Co., Allen's avenue, Providence, R. I. In the accompanying engraving a two furnace Almy boiler is shown.

Seabury Water Tube Boiler.

The Seabury boiler is of the small bent submerged tube type, consisting of a central water and steam drum situated over the furnace and connected by bent tubes with two half manifolds at the bottom, one on each side of and below the grate. The tubes are expanded in place at both ends. The tubes are arranged so that they have the same width of opening between them as their diameter, and by the use of a fire-brick baffleplate the gases are made to flow over the entire upper portions of the tubes. The drum is of plate with riveted joints, and is provided at the front end with a manhole of large size. The half manifolds at the bottom are

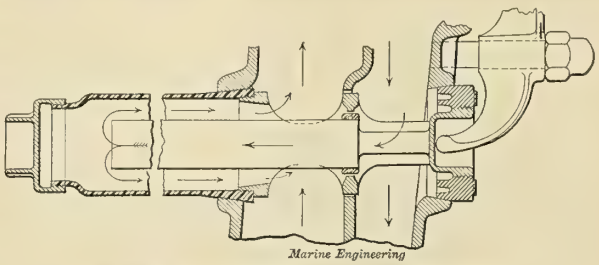


DETAIL OF LOWER MANIFOLD, SEABURY BOILER.

welded up and their top edges are machined true, fitting a groove in the under side of the bottom tube plate. The joint is made by asbestos wick in the groove, and the half manifold is drawn up to the packing by steel bolts and straps. The heads of the bolts are countersunk on the top side of the tube plate, leaving it a smooth surface, so that it can easily be cleaned. Details of construction can be readily gathered by an inspection of the accompanying drawing. On top of the boiler tubes proper there is placed a feed water heater, consisting of straight iron pipes lying parallel with the central drum and connected at the ends with malleable iron screwed return bends. The gases from the combustion chamber pass over these heater tubes before reaching the stack. Wrought iron grate bars of the shaking type are used, and the boiler can be arranged to burn either hard or soft coal or wood. When the boiler is filled ready for operation and the fire is lighted, the heat coming first in contact with the inner row of tubes causes an upward movement of water in these tubes toward the drum. As the heat increases the water in the other rows of tubes follows the same direction, with the exception of the outer rows next the casing. In these the flow is downward to the lower side manifolds, and thus a large area of pipe for returning the water from the upper drum is secured without the use of outside down-flow tubes. Advantages claimed for this system are that the water leaves each side of the upper drum along its entire length and has a comparatively short distance to travel to get back again; also that each tube takes care of its own supply and is not dependent upon any other tube or contrivance for its efficient operation; also, the distance between the tube ends is so small that "the water is practically in circulation in the tubes," and with the free circulation of water sagging of tubes is avoided. It is claimed also that great steadiness of water level is secured, so that when in operation the variation of level would not exceed one inch from standing still to full speed of engine. In larger units a somewhat different design is adopted. In this the central drum is retained, but instead of the half manifolds, steel drums, one at each side, are employed. There is also a vertical row of straight and slightly curved tubes connecting the bottom of the steam drum, its entire length, with a tube of large diameter at the grate level. This center row of tubes divides the grate into two equal sections, making two separate furnaces. This type of boiler is manufactured by the Gas Engine & Power Co., and Charles L. Seabury & Co., Consolidated, Morris Heights, New York City. It is widely used in yachts and launches, and is now being fitted by the builders in the U. S. destroyer *Bailey*, which they have under construction.

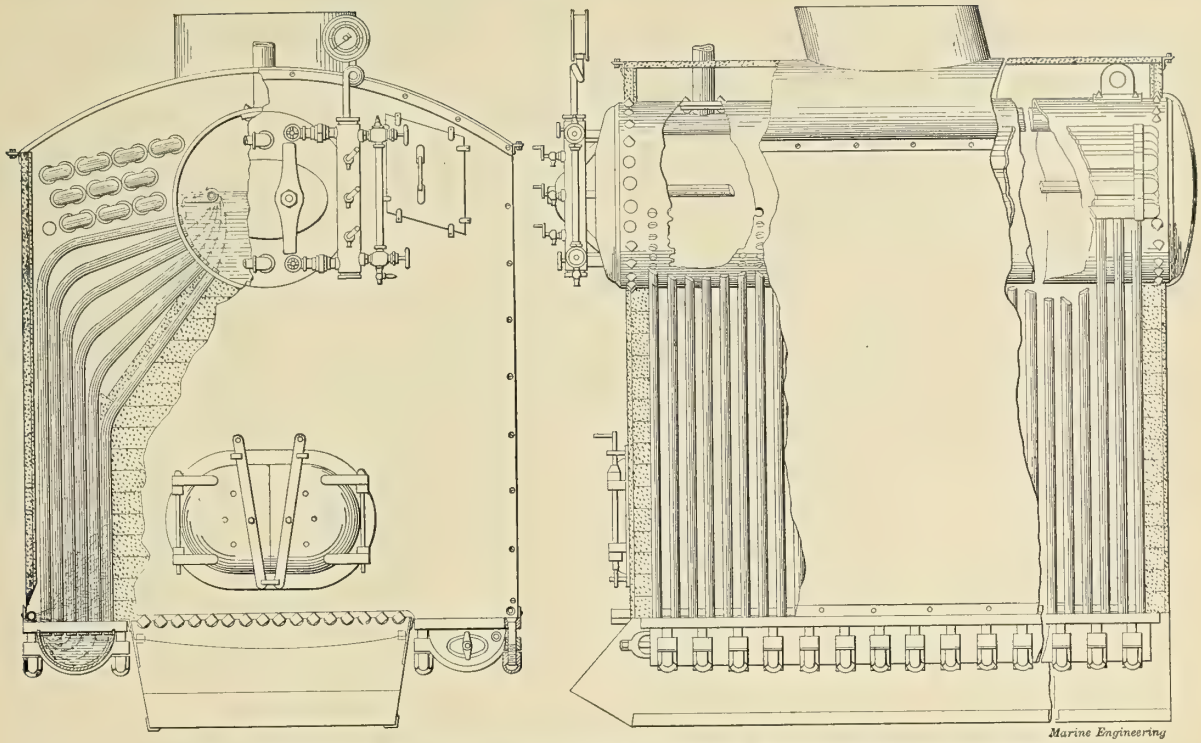
Niclausse Water Tube Boiler.

The Niclausse boiler is of the large straight tube type. "Field tubes" set at an angle of six degrees to the horizontal, are all placed above the grate and are connected at the front and back with vertical headers. The front row of headers is connected at the top with the horizontal steam and water drum which extends across the boiler. The headers are arranged as shown in the accompanying drawings, and are interiorly divided into compartments, as can be seen by reference to the detail sectional drawing. Each tube consists of a pair of tubes placed concentrically, the outer or generating tube being upset at the front end to a diameter slightly greater than that of the tube, and this thickened end is machined so as to accurately fit the tapered tube hole in the rear face of the front header. The back or dead end of the outer tube is swedged and sealed by a steel cap of a diameter slightly less than that of the tube. Attached to the generating tube is a sleeve provided at its outer face with a flexible tapered joint which fits the tapered socket in the front face of the header. This sleeve also contains a smaller

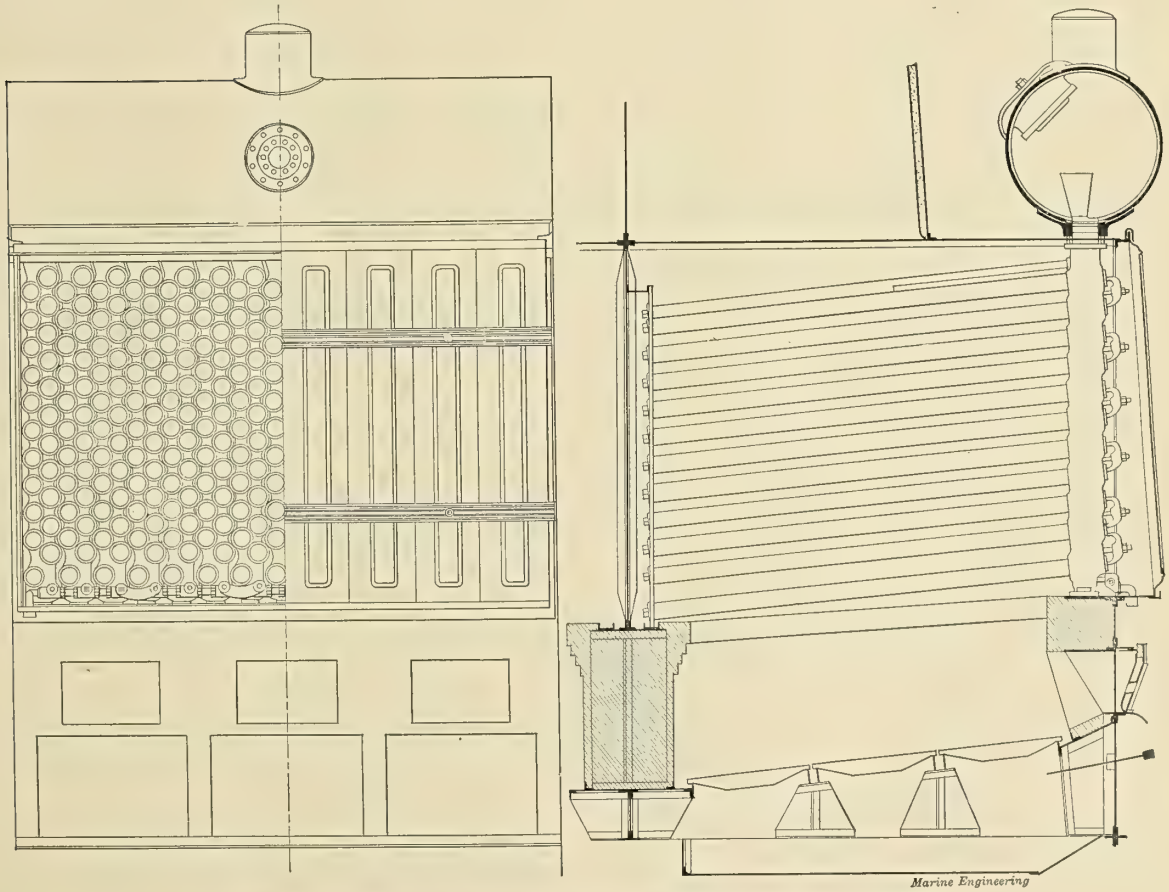


SYSTEM OF CIRCULATION, NICLAUSSE BOILER.

sleeve holding the inner or circulating tube, and the whole—consisting of the outer or generating tube, the main sleeve and smaller sleeve and the inner or circulating tube—is held in place by a dog and studbolt. In the construction expanded joints are eliminated, and



SEABURY WATER TUBE BOILER—FRONT AND SIDE ELEVATIONS WITH CASING PARTLY REMOVED.



NICLAUSSE MARINE TYPE WATER TUBE BOILER—FRONT AND SIDE ELEVATIONS.

the tendency of the pressure when under steam is to tighten rather than strain the joints. Speed in making repairs is claimed for this type. To renew a tube it is only necessary to loosen the dog and withdraw the tube through the front header; then to pass in the new tube, so that the tapered joint of the upset portion of the tube, and the tapered flexible joint of the main sleeve are brought face to face with the tapered faces of the rear and front sockets of the header, and then to clamp the dog in place again. When under steam the feed water enters a tray in the front of the steam and water drum, and is there heated to the temperature of the steam. Overflowing into the drum the water descends to the front compartments of the headers and passes in solid streams down the inner or circulating tubes to the extreme ends of the "field tubes," and here it turns and passes back to the front in the annular space between the inner aud outer tubes. The mixed steam and water then passes upward through the inner compartments of the headers and discharges into the drum. By an arrangement of baffling plates the gases are made to circulate in an S-shaped path among the tubes, on their way from the furnace to the uptake. The boiler is of French origin and has been used extensively in the French and Russian navies. It is manufactured in this country by the Stirling Company, Pullman Building, Chicago, Ill. The boiler shown in the drawing is one of a set recently completed for installation in a Russian warship under construction at Cramp's. Claims made for this type are, among others: Simplicity and accessibility; ease of maintenance and repair; positive circulation; responsiveness to fluctuations in power; dryness of steam; and economy. The design can, of course, be altered to suit special structural conditions as to installation or transportation.

Transatlantic Mail Service.—The continued withdrawal of vessels from the transatlantic service, for use by the British Government as transports during the Transvaal war, has seriously disturbed the regular mail schedules. Large quantities of mail which would have ordinarily come through New York have been sent via Boston by the slower steamers on that route. In consequence of these withdrawals the Cunard line is now obliged to maintain its New York service with only three vessels, the *Campania, Lucania* and *Etruria*. The White Star line has to depend on the *Oceanic*, the *Teutonic* and the old *Germanic* for her mail and passenger service. The American Line is rather crippled also by the temporary loss of the *Paris*. How long this condition of things will last is not apparent, as from present appearances the Transvaal war will be a lengthy affair.

January 3 has been set for the launching of the new Hamburg-American liner *Deutschland*, which is designed to be the fastest liner afloat. She is of 23,000 tons' displacement, and is expected to have a sea speed of 23 knots.

The new Cunarder *Saxonia*, for freight and passenger service on the Boston-Liverpool route, was launched at the Clydebank yard December 16. She will have immense cargo-carrying capacity and moderate speed.

The navy is now short about 4,000 men of the 20,000 allowed by law.

BOILER ARRANGEMENTS OF RECENT BRITISH AND FOREIGN CRUISERS.*—II.

BY F. T. MARSHALL, MEMBER.

Next dealing with the question of boiler-room work, we find that, on the basis of the natural-draft power, the two water-tube types are substantially lighter than the cylyindrical type, the Yarrow type being the lightest. On the basis of the maximum power the advantage of the Yarrow type in this respect is enormous, whereas the Belleville type is not materially lighter than the cylindrical, owing to the fact that it is not forced. Thus, on a given weight, the Belleville type will develop, with natural draft and for long periods, approximately the same power that the cylindrical type will develop for short periods of a few hours under extreme forced draft. Also, on the same weight, the Yarrow type will develop 14 per cent more than the Belleville for long periods, and 78 per cent more for short periods. Again, comparing the Yarrow with the cylindrical, it is seen that it will develop 50 per cent more power for long periods, and 65 per cent more for short periods, on a given weight.

These comparisons are based upon total boiler-room weights, including water in boilers plus water in the feed tanks, and also such fittings as reducing valves, separators, etc., which form an intrinsic part of the boiler systems. The separate weights of boilers and funnels, water, and boiler-room accessories are also given, and it may be noticed how relatively high the weight of accessories is in the case of the Belleville type, owing to the numerous special fittings which form part of this system.

FORCED DRAFT.

A crucial point in the above comparisons of space occupied and weight is the question of how far forced draft can safely be used in the usual exigencies of service, or even in the extreme case of war. As to the Yarrow boiler, the writer submits that, as far as the boilers are concerned, this type may safely be forced to an air pressure of, say 2 in. (the maximum employed on the *Don Carlos* trials) so long as the coal lasts. Working under these conditions is, however, very severe on the personnel of the stokeholds, and the endurance of the men would probably be found to be the measure of the time during which this power could be maintained.

In the case of the cylindrical boilers a four hours' run is probably as long as these boilers could be worked at the maximum forced-draft power. These boilers have a tendency to suffer in the flame-box seams when long firebars are used, and it is only by the use of these long bars that the high powers looked for can be obtained. The tube ends also get choked up, especially if fitted with ferrules, and without ferrules the tubes have a great tendency to leak. It is probable that at the end of four hours the boiler efficiency will be seriously affected, and the power could not longer be maintained. On the other hand, however, the high speed obtained during these four hours might mean the salvation of the ship, and it is unfair to overlook this advantage.

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*Paper read before the Institution of Naval Architects, England.

It should be understood that the above remarks do not apply to forced draft applied to cylindrical boilers with moderate length of firebar, say 5 ft. 6 in., and with a heating surface of 2 1-4 ft. per indicated horse power. Such boilers can be worked at about 17 indicated horse power per square foot of grate continuously at sea; but their size and weight would preclude their use in the type of vessel considered, as the power obtained would only correspond approximately to the results obtained in the 1-2 in. air-pressure trials of warships.

RAISING STEAM.

The rapidity with which steam can be raised, and the ready response to sudden demands in variation of power, are two matters of utmost importance in war vessels, and in both of these the water-tube types show a marked superiority over the cylindrical boiler. The large quantity of water contained in the latter makes it a question of hours to raise steam; and, if this operation in hurried, the boilers are strained to a serious extent, causing leakage. The same course of reasoning applies, though to a less degree, to any sudden and rapid large variation of power.

As to the two water-tube types, in both cases steam can be raised to full pressure in about thirty minutes from lighting fires. In the matter of variation of power there is also little to choose between them; for, although the large grate area of the Belleville type is an advantage, the safety with which the Yarrow type may be suddenly forced compensates for it.

LIABILITY TO DERANGEMENT IN WORKING.

In this respect, apart from the difficulties mentioned under extreme forcing, the cylindrical type is to be preferred. All the arrangements, both of the boiler itself and of its accessories, such as the feed and steam-pipe systems, are simpler than in the water-tube types. The boilers are fewer in number, thus reducing the number of pipes and connections, and the consequent liability to leaky joints, etc. The feeding is also less critical, owing to the large water level. In addition to this, the introduction of salt water, even in considerable quantities, owing to leaky condensers or other causes, has little appreciable effect upon the working of the boilers. Although, to obtain maximum results, these boilers must be in a state of thorough repair and cleanliness, they are still serviceable after considerable neglect such as would render any water-tube type useless.

With regard to the Belleville boiler a grave objection, in the writer's opinion, is the enormous mass of mechanical detail in connection with them. Thousands of joints, all dependent upon extreme accuracy of workmanship, and many of them subject to extreme strain, due to varying temperature, are a pronounced feature in the design of this type. These points have been well met in the methods of manufacture, but most rigid supervision is required to maintain the accuracy necessary. The feeding is also extremely delicate, owing to the small quantity of water contained, and also variable weight of this water at different rates of evaporation. This latter condition necessitates the introduction of the hotwell pumps and large feed tanks already described. The feed regulator employed, which certainly works admirably, is nevertheless, a delicate mechanism, and has to be kept in a high state of efficiency. The number of boilers is also great for the power developed. This large subdivision has the advantage of involving only a small reduction of power, should one boiler become inoperative for any reason; but it certainly causes an enormous addition of important detail, such as feed-pipe and steam-pipe arrangements, all requiring care and attention. The furnace air-pumping engines are also an additional complication, involving many extra fittings. Whether these objections are valid, extended experience alone can show, and it is an unquestionable fact that the vessels fitted with these boilers, especially since the addition of economizers, have passed through most severe trials with consistent success.

Referring to the Yarrow type, the construction in this case is extremely simple. None of the riveted seams are in direct contact with the fire, and the strains due to changes of temperature are not severe on the parts of the boiler under pressure, especially if the outer rows of tubes are curved. The casings are probably the most severely tried part of the boilers, but no trouble need be feared from these, if carefully designed.

The great question about this and other small-tube types is the life of the tubes, owing to their comparative thinness. Any information which any gentleman could give us on this point would be of extreme interest.

The tubes of the *Don Carlos*, as before stated, are .128 in. and .104 in. thick for the 1 3-8 in. and 1 1-3 in. tubes respectively. They are galvanized externally only, as is usual for this class of boiler in the British navy. Mr. Yarrow, on the other hand, invariably galvanizes the tubes both internally and externally, but this does not appear to be necessary in the case of a boiler with drowned tubes. It is probable that one cause of wastage on the outside of the tubes is the method of steam cleaning usually adopted in these boilers. This steam jet leaves the tubes damp, which naturally aggravates any tendency to rust. In the *Don Carlos* the tube-sweeping arrangement was taken from the compressed air pipes used in connection with the armament. This gives a perfectly dry air jet at high pressure, and proved a most efficient cleaner without the above objectional feature. The feed system already described has the disadvantage of a large number of pumps, but in all other respects is very simple and unlikely to become deranged. The area of water level also is large relatively to the quantity of water in the boiler, and this area is naturally the measure of the difficulty of steady feeding.

As to the possibility of working with salt water as make-up feed, our experience has certainly been against it in both the water-tube boilers considered. A serious tendency to prime, except at very low powers, is produced by even a small admixture of sea water, and anything approaching continuous use would be, in the writer's opinion, most undesirable. This is evidently borne out by experience, as the Admiralty have recently taken special precautions in all their vessels to minimize the risk of salt water entering the boilers through inadvertance, or without the special knowledge of the officers in charge.

FACILITY OF OVERHAUL.

In this respect the Belleville type has a great advantage, viz., the readiness with which complete elements can be taken from the boiler, repaired in the stokehold, and replaced. The other parts of the boiler are also of

small dimensions, and, in case of a serious accident, the whole boilers can be taken out of the ship through the usual air casings without disturbing decks, etc., and with very slight derangement of even the minor fittings. The examination of the inside of the tubes, however, involves breaking and re-making a large number of joints.

As to the Yarrow type, the operation of renewing a tube is by no means difficult, although if the defective tube is in the middle of a nest, all the tubes between it and the outer edge of the tubeplate must also be removed. The method adopted is to work the tubes from hole to hole alternately between the two tubeplates until the outer edge is reached. If, however, time is of importance, the tube ends can be plugged and steam raised again rapidly without any injury to the structure. whole of the protective deck and superstructure in way of the boilers has to be removed.

STEAM PRESSURE.

With the water-tube types, the pressure of 300 lb. per sq. in. is now customary. Such pressures are not practicable, except with water-tube boilers, without enormous increase of boiler weight, and they have the advantage of enabling smaller engines to develop the necessary powers, with the attendant advantage of relative economy at low powers. In cylindrical boilers the best balance of weight, power, and space economy appears to be obtained by using about 155 lb. steam pressure. The additional economy in the engines, by using such higher pressures as are possible with these boilers, is not sufficient to justify the additional weight of boiler due to such higher pressures in vessels in which

COMPARISONS OF BELLEVILLE, YARROW, AND CYLINDRICAL BOILERS.

Name of Ship	*Andromeda.*	*Hermes.*	*Don Carlos I.*	*Hai Chi*	*Æolus.*	*Pallas.*
Number and type of boiler fitted	30 Belleville	18 Belleville.	12 Yarrow.	8 cylindrical 4 D.-E. and 4 S.-E.	5 cylindrical 3 D.-E. and 2 S.-E.	4 cylindrical D.-E.
Steam pressure in pounds per square inch	300	300	300	155	155	155
I. H. P. with natural draught*	16,500	10,000	8,000	12,000	7,000	5,000
" " forced draught	.....	.....	12,500	17,000	9,000	7,500
Total heating surface in square feet	40,140	24,050	32,004	27,558	15,947	11,040
Heating surface per I. H. P. natural draught	2.44	2.405	4.0	2.3	2.28	2.2
" " forced "	.....	.....	2.56	1.62	1.77	1.475
Total grate area in square feet	1439	750	587	940	560	406
Length of firebars	6 ft. 3 in.	6 ft. 3 in.	7 ft. 3 in.	7 ft. 1½ in.	7 ft.	7 ft. 3 in.
I.H .P.per square foot of grate,natural draught	11.47	13.33	13.6	12.78	12.5	12.3
" " " " forced "	.....	.....	21.3	18.1	16.05	18.4
Total boiler-room area in square feet	4925	3100	2440	3470	2230	1900†
I. H. P. per square foot of boiler-room area, natural draught	3.35	3.22	3.28	3.46	3.14	2.63
I. H. P. per square foot of boiler-room area, forced draught	.....	.....	5.12	4.9	4.03	3.94
Heating surface per square foot of boiler-room area,	8.15	7.77	13.1	7.94	7.16	5.82
Grate area per square foot of boiler-room area	.292	.242	.24	.276	.251	.214
" " " on basis 6 ft. 3 in. bars	.292	.242	.207	.242	.22	.185
Total weight of boilers, uptakes, and funnels, in tons	559	342	217	447	270	174
Total weight of water in boilers, in tons	43	30	30	197	103	82
" pumps, pipes, connections, water in feed tanks, &c., in tons	168	100	82	97	55	41
Total weight in boiler-rooms in tons	770	472	329	741	428	297
Weight in boiler-rooms in pounds per I. H. P. natural draught	104	105.5	92.2	138	157	133
Weight in boiler-rooms in pounds per I. H. P. forced draught	.....	.....	59	97.4	106.3	89
I. H. P. per ton of boiler-room weight, natural draught	21.4	21.19	24.5	16.2	16.4	16.8
I. H. P. per ton of boiler-room weight, forced draught	.....	.....	38.0	22.9	21.1	25.2

* Natural draught here implies the usual Admiralty conditions, in which an air pressure of ½ in. of water column is permitted.
† Boiler-rooms very large in this vessel.

The inside of the tubes can be readily seen through and cleaned, owing to their being straight. This examination is merely a question of minutes, and thus is likely to be more frequently made than if considerable time and trouble were needed. It also involves the breaking of no joints, except the manhole doors. The outsides of the tubes are certainly not easily examined, and it is wise from time to time to remove a tube here and there to judge of the condition of the remainder. In the case of a serious accident, or serious neglect, necessitating the retubing of a large portion of the boiler, the process would doubtless be slow. It is not a contingency likely to arise, and in any boiler would necessarily be a dockyard repair. Referring to the cylindrical boiler, the capabilities of this type for ordinary examination and overhaul are well known. For heavy repairs, however, such as renewing a furnace or flamebox, the process is both tedious and costly, and in the extreme case of removing a boiler from the ship the coal consumption is to some extent of secondary importance.

GENERAL CONCLUSION.

The comparisons made appear to lead to the following general conclusions in the case of the three types of boiler considered, starting on the basis of equal space occupied.

The Belleville type is well adapted for maintaining high continuous sea speeds for long periods, and is very economical at high powers. It is comparatively light and well arranged for cleaning and overhaul. Steam can be raised quickly, and large variations in power made readily. It cannot, however, be forced, and has also the objection of great complication of detail and accessories, with consequent liability to derangement.

The Yarrow type is hardly so well adapted for continuous steaming at relatively high powers, and is not so economical under such circumstances. It can, how-

ever, be forced to almost any extent with safety, and much higher speeds obtained for considerable periods. Steam can be raised quickly, and large variations in power made readily. It is extremely light, and, being simple in detail, has small liability of derangement. Cleaning and overhaul are fairly easy, but the examination of the outside of the tubes is difficult.

The cylindrical type is about equal to the Yarrow for continuous high-power steaming, though probably slightly less economical. At low powers, however, it is very economical. It can be moderately forced with safety, and is well adapted for ordinary cleaning and overhaul. All its arrangements are extremely simple and unlikely to become deranged. Sea water can be used in it with safety. It is, however, heavy; steam can only be raised very slowly, and large variations in power cannot be made quickly.

The foregoing conclusions, the writer submits, point to the fact that the boiler question is one which must be dealt with in its relation not only to each individual class of ship, but to each individual service. The adoption of any type will depend upon what particular qualities are most desirable for the boilers to possess to meet the special work which the vessel is designed to do. The general naval policy of any Power will thus have a direct bearing upon the question of what type of boiler is preferable for a given ship.

In conclusion it may be added that the three types considered are given merely as a comparison of actual examples of typical boilers, and are not put forward in any spirit of comparison with other types of boiler or other systems of working.

† More recent Yarrow boilers, fitted with Mr. Yarrow's feed heating arrangement, are fully equal to the Belleville type in economy.

Breakdown of S.S. Waikato.

The British steamship *Waikato* from London to New Zealand ports reached Fremantle, West Australia, recently after a voyage of 157 days. When the vessel had been out of port a month the machinery broke down, and though temporarily repaired was finally altogether disabled by the fracture of the tail shaft. As she would not steer her condition was very serious, and she was driven about for 30 days until sighted by a sailing ship. The vessel tried to take the steamer in tow, but as the weather was unfavorable did not succeed, and finally sailed away taking with her the news that the steamer was helpless. As the result of this information a British cruiser was sent out from Mauritius to look for the *Waikato,* but did not succeed in finding her. The *Waikato* was subsequently sighted by several vessels, among which was the *Alice,* of New York, which supplied the disabled steamer with sails and provisions. About the middle of September the steamship *Asloun* came up and took the *Waikato* in tow. The *Asloun* was short of coal and, consequently, with her tow she proceeded to Amsterdam Island where in sheltered water a large quantity of coal was transferred in the ships boats from the *Waikato* to the *Asloun.* Then the voyage was resumed, not without incident, however, for before reaching the Australian ports the tow ropes parted and the vessels lost sight of one another on one occasion. It is greatly to the credit of those on board the disabled vessel that entire harmony prevailed in the trying time adrift.

COMPARISON BETWEEN PERFORMANCES OF TWO SEA-GOING STEAMSHIPS.*—II.

BY J. D. M'ARTHUR, MEMBER.

On account of slight corrosion manifesting itself in the boilers, and being ascribed to air amongst the feed-water, the main internal feed pipes were turned up so as to discharge the water into the steam space, at a considerable height above the water level. It is doubtful, however, whether air was really the cause of the corrosion, for amongst its other good qualities, Weir's heater rids the water pretty effectively of any air it might contain, and moreover, in the case under consideration there was little or no air in association with the water during any part of the cycle.

The boilers of both steamers were very similar in all particulars save one, namely, that those of A had an extra dead-plate about 9 in. long fitted to each furnace and the whole grate shifted back this amount. The result of this was that during two years not a single baffle-plate required renewal or repair of any sort beyond cleaning the perforations, and were as effective in promoting an equal distribution of the air to all parts of the grate as when new. On the other hand, it must be taken into account that the grate being virtually 9 in. longer, that is, the bridge being further from the furnace mouth, rendered good stoking rather more difficult, especially when the coal formed a heavy clinker, as often happens with forced draught. Little difficulty was found, however, in the actual working, even with Lascar firemen.

In the case of B, whose furnace dead-plates were of the ordinary length, the baffle-plates in proximity to the glowing fuel soon burnt out, and the complete set required renewal on an average every nine months. Further, the author is of opinion that this militated to a certain extent against the economical working of these boilers, for when one side plate gave out, as very often happened, the greater body of the air following the path of least resistance would naturally pass to that side of the furnace, and issuing in bulk, as it were, could not mix so intimately or immediately with the products of combustion as when entering in finely divided streams over the whole of the combustive area.

The ratio of heating surface to grate area was practically the same in both ships, being about 52 to 1. The tubes were 2 1-2 in. dia., 8 ft. 9 in. and 8 ft. 4 in. long and fitted with retarders. In A's boilers the grate area (117 sq. ft.) was reduced to 100 sq. ft., by increasing the length of the bridges. In B's, the actual area was about 90 sq. ft., so that in the first case the consumption per square foot of grate per hour averaged 18 lb., and in the second 22 1-4 lbs., the air pressures in each case being, at fan, A, 1 in. to 1 1-4 in.; B, 1 3-4 in. to 2 in.; ashpits, 3-4 in. and 1 3-8 in., and in furnaces, 1-4 in. to 3-8 in. and 3-4 in. to 1 in. respectively. Not being provided with pyrometers it was impossible to find the temperature of furnaces, uptakes, etc., but a comparison of the two funnels suggested an experiment to the author which he thought might be worth a trial. The heights of the funnels were, A, 70 ft., and B, 63 ft. 6 in.; the velocity of the escaping gases would vary

* Read before the Institute of Marine Engineers, London England.

as the square root of the heights in feet, or as 8.37:8; on the other hand, B's funnel, whose diameter was 8 ft. 3 in., had an area of 121 times the area of A's, whose diameter was only 7 ft. 6 in., the total quantity of gases escaping at the same temperature would be proportional to the area and velocity, in other words, the quantity delivered by B would be $\frac{1.21}{1.046} = 1.16$ times that escaping from A, neglecting entirely the greatly increased air pressure in the furnaces, which would still further augment the disproportion; the fuel burnt in B's furnaces being only 1.13 times A's consumption. The suggestion intended was, that had a damper been fitted in the funnel, it might have been possible to find one particular area which would give the best result by checking the apparently too great flow of gases, to aid more perfect combustion and bring them more intimately into contact with the heating surfaces by imposing, as it were, a slight pressure in combustion chambers and tubes.

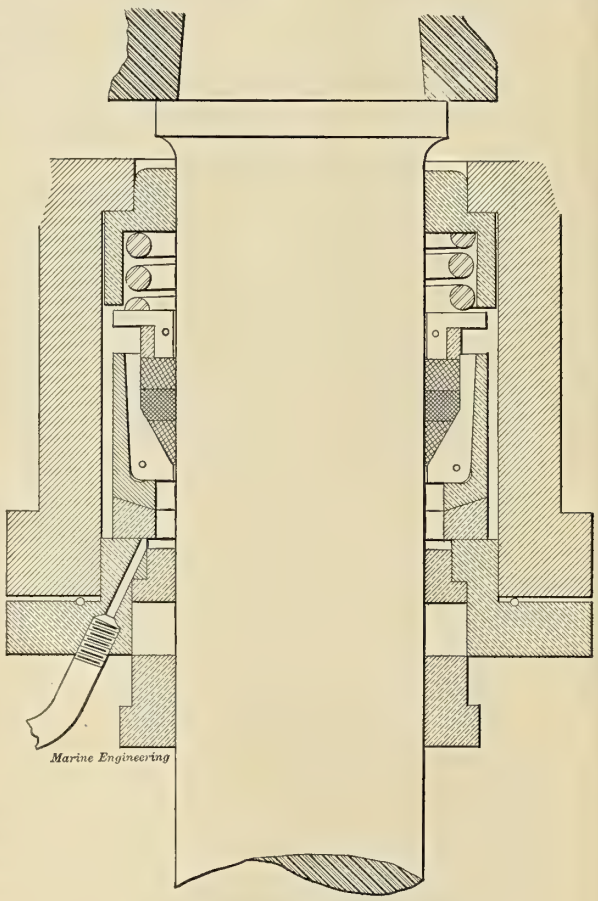
In B's engine-room and stokehold it must be admitted that the bad points outweighed the good ones, or at least, as happens very often when other things than machinery are under notice, they occupied the most prominent position. Dirt in an engine-room is to be avoided as far as possible, not only so from appearance sake as on account of its pernicious effect on all wearing surfaces. Anyone who has been at sea with boilers working under Howden's forced draught must know how extremely difficult it is to prevent dust from getting into the engine-room, particularly when there is only a thin screen bulkhead between the boiler backs and the engine-room, as is the usual mode of construction; and the reason is not far to seek, either, for while with natural draught the direction of the air-currents is in towards the ash-pits, with forced draught the ash-pits are closed, and the fan, being in most cases situated in the engine-room, causes an in-draught of air through skylights, ventilators and crevices in bulkheads, the latter being often effectually aided by the stokehold ventilators trimmed to the wind. There was no tank below the boilers or engines in the arrangement of B, and the screen-bulkhead extended no lower than the engine-room platform, leaving a free inroad for coal dust, ashes and hot vapor from clearing fires, while to make matters worse, the only means of egress above the boilers was through two small mushroom vents. This had also the effect of rendering both engine-room and stokehold almost unbearably hot—a temperature of 140 deg. in the engine-room and 145 deg. to 150 deg. in the stokehold being not uncommon east of the Suez Canal—a factor very much against the human element concerned in the economical working of boilers, and especially careful stoking, which is doubly important in boilers with forced draught, for, if the bars be not evenly covered to a uniform depth in all the furnaces, the thinnest fires, or parts of the fires, will burn through first, and offer a freer passage to the air under pressure in the ash-pits, thereby retarding the combustion of the thicker parts of the fuel, and eventually lowering the temperature of the furnace or furnaces by admitting a quantity of uncombined air to cool down the products of combustion.

(To be continued.)

IMPROVED APPARATUS.

Torpedo Boat Engine Packing.

Our engraving shows a special design of metallic packing made for two of the torpedo boats now building for the U. S. Navy, in which the initial pressure is 250 lb. per sq. in. This packing is an adaptation of the standard "United States" metallic locomotive packing to marine work. In the form adopted for locomotives it is in widespread use with boiler pressures as high as 210 lb., and has proved thoroughly satisfactory. The packing here illustrated has in addition to the locomotive fittings a small supplementary stuffing box placed in the main gland, so that a few turns of soft packing can be used. This, however, is to act as a swab or device for holding the lubricating material between the stuffing box and the main packing, rather than a preventive of the leakage of steam. The main packing takes care of the latter, though the only metal parts allowed to come into contact with the rod are the special composition rings. It will be noticed that the vibrating cup, which is the part holding the rings, is of unusual construction, so as to permit of the packing being applied to a rod with shoulders at the piston and cross head ends, such as used in a torpedo boat engine. The outside end of the vibrating cup is solid and made of steel, and the smallest internal diameter is large enough to fit over the shoulders of the piston rod. Inside of the cup two half pieces are fitted

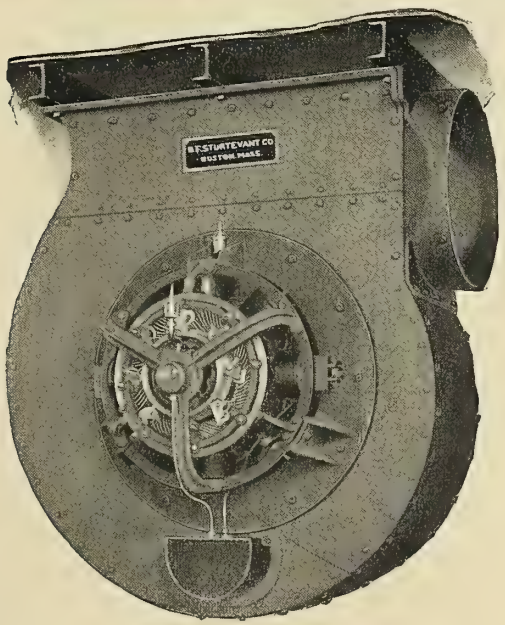


UNITED STATES METALLIC PACKING.

and within these are the metal packing rings. The connection is shown in the drawing for a forced feed lubricating device, and by an arrangement of small valves in the connecting pipes this orifice can be used as a drain to pass off any accumulation of water of condensation. In an emergency fibrous packing can be used in the vibrating cups instead of the metal rings, though, of course, this would not be efficient for continuous service. Various forms of marine engine packing are manufactured by the patentees, some of which are specially useful where the clearance spaces are small and the stuffing boxes shallow; a difficulty frequently met where it is desired to substitute metallic for fibrous packing. The manufacturers are the United States Metallic Packing Co., 427 North Thirteenth street, Philadelphia, Pa.

Suspended Electric Fan.

One of the prime advantages of an electric fan is its adjustability. Not only may it be located where most convenient for the adjusting of piping, but it may readily be constructed in such form as to be supported or suspended as may best suit the conditions. The accompanying illustration serves to make clear this point, for it represents an entirely new design built upon a special order by the F. F. Sturtevant Co., of Boston, Mass. The fan as here shown was designed for use on shipboard, and is suspended from the deck. In general form the fan itself is of the usual steel plate construction, being an exhauster with the inlet on the side farthest from the motor. The motor itself is of entirely special construction, having eight poles, rendering it very compact, so that it extends the minimum distance from the side of the fan. In the size here shown, the field ring was of wrought iron, although



STURTEVANT SUSPENDED ELECTRIC FAN.

in larger sizes it is built of cast steel or cast iron. The cast iron plate with projecting lugs which is attached to the fan side serves to center and hold in position the field ring of the motor, while tripod hangers extending from either side of this ring support the armature shaft in ring oiler boxes. The field cores are of wrought iron, giving the highest efficiency to the field, and the pole shoes are of cast iron of such peculiar shape and size as to render the machine capable of extreme variation of load without sparking at the brushes, and without any shifting or adjustment whatever. The field coils are machine wound, and thoroughly insulated, their form being thoroughly open. The windings present a maximum amount of radiating surface, which results in the most perfect ventilation, and prohibits any great amount of heat. The armature cores are built up of laminated, slotted discs mounted on a cast iron spider, having a hub projection for the reception of the commutator. These core discs are solidly clamped between two brass rings which have corresponding core teeth. The armature is of the core wound drum type, and in the usual form has a two-circuit winding, although in some cases multiple winding is used. This type of winding on machines of low speed and small output is of great advantage. The commutator is of large diameter, and consists of pure rolled or drop forged copper segments supported in a cast iron shell of spider construction, and thoroughly insulated. Reaction brushes of fiber graphite are used, and supported by special rigging. These motors require no shifting of brushes from no load to full load, thereby greatly reducing the attention required. Fans of this type can be constructed in various sizes and forms, and motors can be provided having capacities ranging from three to 125 horse power.

Loss of S. S. Ariosto.

A sad and apparently needless loss of life resulted from the stranding of the British steamer *Ariosto,* which went ashore about six miles south of the Hatteras life saving station on the Atlantic coast, December 24. The *Ariosto* was a vessel of 2,265 tons and was bound from Galveston to Hamburg via Norfolk, laden with cottonseed products and grain. She lost her bearings in the fog and was blown ashore by a heavy gale. After the vessel stranded the crew sent up rockets and at daylight attempted to get away in the boats. Three boats left the ship, but were swamped and all occupants were drowned in sight of the life saving crews from the Hatteras and Ocracoke stations, which had come down to the beach. The captain and eight of the crew remained on board of the vessel, and after several attempts the life savers succeeded in reaching them with a line fired from the Lyle gun. When connection with the vessel was secured the breeches buoy was sent out and those on board were brought ashore in safety. The number drowned exceed twenty.

S. S. Paris.—It has been decided to thoroughly repair the S. S. *Paris* and put her back on the New York-Southampton route of the American Line. The contract for the work has been made with Harland and Wolff, of Belfast, Ireland, who have had considerable experience in this class of work. The most notable case, perhaps, in which they repaired a seriously damaged vessel was that of the P. & O. liner *China.* It is probable that new machinery will be fitted in the *Paris* while the repairs to the hull are going on. The vessel will be renamed for an American city when she goes into service again.

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SECRETARY OF THE NAVY John D. Long, in his annual report recommends the consolidation of the present separate naval bureaus of Construction and Repair, Steam Engineering, and Equipment under one head—the Bureau of Ships. The Secretary is careful to state that the change is recommended on systematic and not on personal grounds, though to those familiar with the present conduct of the bureaus such an explanation would not be necessary. The terms of office of the present chiefs of the three bureaus will expire in little more than a year, and it is suggested that the change be not carried into effect until that time. At first sight this proposal seems very radical, but after consideration it appears to be a natural sequence to the enactment of the Personnel Bill. That bill practically abolished the Engineer Corps, and left, therefore, the Construction Corps as the only titular engineer (mechanical) corps of the Navy. It has been the contention of representatives of the former Engineer Corps that the bill practically operated to expand the Engineer Corps, so as to take in all line officers, rather than to permit the deglutition of the engineers by the line. This last seems to be recognized by the executive heads of the Navy, for, we are informed, since the passage of the Personnel Bill assignments have been made of former engineer officers to line duty, but none of line officers to exclusively engineer duty. The broad statement that in the future every naval officer afloat must be an engineer has been iterated and reiterated. This, we believe, is so to a limited extent so far as operation is concerned. Construction is another matter altogether. Returning again directly to the proposal of the Secretary of the Navy; of the three bureaus named, those of Engineering and Equipment are now controlled by line officers, while the Bureau of Construction is distinctively an engineering bureau with functions of a technical character, and its membership wholly removed from any participation in combatant duties or responsibilities. In the natural order of things it would mean, therefore, that consolidation of the bureaus would result in the ultimate direction of affairs by members of the Construction Corps. Among the present members of this corps are several who have been trained as naval engineers and have this knowledge in addition to their attainments as naval constructors. This would not probably be the immediate result, for, of course, there are now in the ranks of the combatant officers many highly skilled and experienced men who formed the late Engineer Corps, and whose services will undoubtedly be continued along the lines of their training. But as these officers are retired and the present and prospective cadets come to fill their places, in the combatant ranks, the latter will not be nearly so well qualified for the work of construction as the members of the highly specialized Construction Corps. There is another department, however, which we believe the Secretary might have included in his consolidation scheme with advantage to the Navy, and that is the Ordnance Bureau. This is just as much an engineering bureau and, rightly, just as little a combatant officers' bureau as the department of steam engineering under the old order of things ever was. There is very little in the construction of modern guns and armor that calls for high qualifications as drill master or navigator on the part of any one engaged in such work. A gunmaker is a mechanical engineer just as much as a builder of steam engines, no matter what he may be officially styled. The Secretary of the Navy says that when a contract for the construction of a ship is made it is made with one builder, and not given part to a ship constructor, part to an engine builder and part to an outfitting firm. Quite true, so far as it goes, but it is also true

that the most modern development of the warship building business is for one concern to build, arm and equip the vessel; so that all she needs is to take on coal, ammunition, stores and crew, and go out complete to give battle. The most notable example in the shipbuilding world is the Armstrong-Whitworth combination, and there is also the Vickers consolidation, and still later the arrangement between John Brown & Co. and the Clydebank yard as to armor. With such combinations it is reasonably within the possibilities to get the "adaptation and harmony of movement" suggested, and that convergence of effort toward the apex of perfection which is not possible by any system of parallel authority.

A NOTE of alarm is sounded by Engineer-in-Chief George W. Melville, U. S. N., in his report for 1899 concerning the results which the Personnel Bill, in actual operation, will produce. The interpretation of a law by persons entrusted with its enforcement is not always in accordance with the views or intentions of those who created it. Much depends upon the view-point of the individual, the character of his training and environment. It was apparently the intention of the Engineer-in-Chief and his advisers that on the bill taking effect the "whole trend of detail would be toward the complete amalgamation of line and engineering interests in the navy with the most favorable outlook for the protection of the rapidly advancing engineering science." Considering that the enactment of the bill was the result, chiefly, of an agitation commenced by the engineers, and that the compromise which produced the bill was the consolidation of the numerically small engineer corps with the numerically large line, it might reasonably be supposed that the former line, pure and simple, would be the controlling influence. This is a country of majority rule and, so far as matters have gone, the tendency seems all in the direction of the establishment of slightly enlarged line duties for all naval officers afloat, and the relegation of the exclusively engineering functions to enlisted men—the warrant machinists. No doubt the line officer would be quite willing to exercise such supervision in the machinery spaces as he now gives in the dynamo room. We believe that this is all that could in reason be expected of him. The ideal naval officer is of a different habit of body and mind from the scientific engineer; and life below, amid semi-darkness, heat, dirt, disagreeable smells, and the like, is little to the fancy of the genuine seaman—no more in the navy than in the merchant marine. A continuance of this policy would, therefore, place the real burden of responsibility upon the shoulders of the warrant machinist without giving him, under present regulations, any of the rights or privileges of the commissioned officer. How long any self-respecting body of men, such as would be qualified to take responsible—not nominal or official—charge in the engine room of one of our battleships or cruisers would tolerate this anomalous condition is something we would not care to predict. That the Engineer-in-Chief recognizes the human nature of the case is shown by this statement in his report:

> I feel it necessary to draw your attention to the necessity of governing the duties of this new grade of mechanics in such a way as will secure to the service their continued skillful assistance as direct operators and repairers of machinery. With the official elevation which comes with a warrant there is not unreasonable apprehension that these men will desire a severance from actual manual care of the machinery of our ships, and will expect to act merely as engineering supervisors below. This, of course, would be wholly inconsistent with the interests of the service, as at no previous time in naval history has there been a greater demand for the highest mechanical skill in the persons of those who have direct charge of marine motive power. Clear and definite regulations are needed on this point at the start, in order that no ambiguity may foster discontent with simple duty or lead to hopes of further official elevation. The engineer officer is and must be the line officer of the future; the warrant machinist must recognize the necessity of his expert mechanical work as well as the distinction he is given by reason of his excellence in it.

If the warrant machinist in the future finds that he is carrying on the work, afloat, which in times past was the duty of the commissioned engineer officer it is difficult to see how he can be, fairly, prevented from demanding a more dignified position among the personnel than that of an enlisted man. His qualifications should certainly be not less than those possessed by the volunteer engineers who at the close of the Civil War were transferred to the commissioned ranks of the naval corps of engineers. It should not be forgotten that it was distinctions of rank, more than anything else, that caused dissatisfaction among the members of the late Engineer Corps and led to the enactment of the Personnel Bill. History repeats itself.

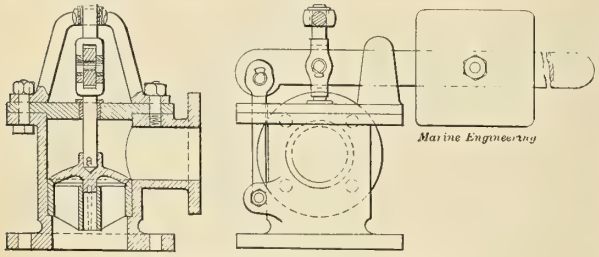
HELPS FOR CANDIDATES FOR MARINE ENGINEERS' LICENSES—BOILERS—III.

BY DR. WILLIAM FREDERICK DURAND.

§ 2. MATERIALS AND CONSTRUCTION.

[5] Boiler Mountings.

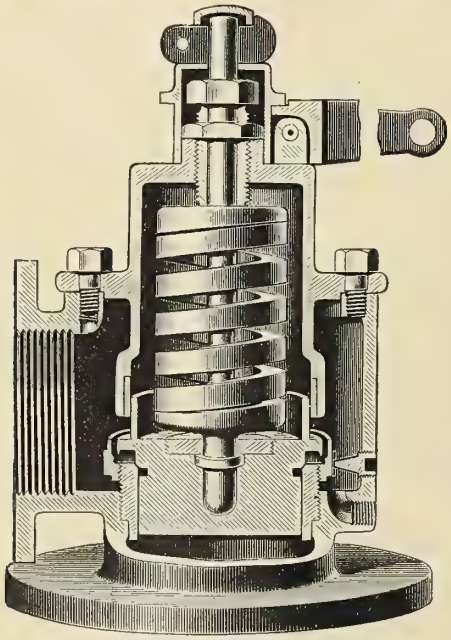
Safety Valves.—The purpose of the safety valve is to provide for the escape of the steam in case the pressure should tend to rise above the safe working limit for which the valve is set. There are two kinds of safety



U. S, STANDARD SAFETY VALVE.—Fig. 1.

valves, known as *lever* and *spring* valves, according as the valve is kept down on its seat by a weight on a lever or by a powerful spring under compression. Fig. 1 shows the construction of the standard U. S. lever valve.

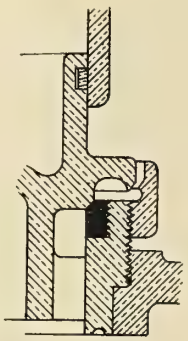
The valve itself has a plain conical face, and fits to a corresponding seat as shown. In its motion up and down it is guided by the double stem, so that it can by no means become jammed in the chamber. The pressure of the steam comes on the bottom of the valve, and as it reaches or passes the limit for which the adjustment is made the valve lifts and the steam escapes about the edge, and thence is led by the escape pipe to the deck. The actual lift of a safety valve is very small,



SPRING SAFETY VALVE.—Fig. 2.

1-8 in. being usually a large lift. The opening for the escape of the steam depends, therefore, on the circumference of the valve and on the lift, rather than on the area and lift. Safety valves are, however, usually designated and determined according to their area. The weight acts by means of the lever, as shown, and may be adjusted so as to allow the valve to open at the pressure desired.

In modern practice the lever valve is infrequently used, except in vessels engaged in smooth water (river) service, the spring valve being fitted almost universally. In this form of valve, which is shown in Fig. 2, the chief point of difference is in the substitution of the spring for the weight and lever. The tension of the spring is adjusted by a screw at the top, so that the valve will not open until the limiting pressure is reached or exceeded. It is readily seen that as soon as the valve rises the spring is compressed and the tension is increased. It is also found that with the plain form of valve, as shown in Fig. 1, the pressure on the face decreases the instant the valve lifts. Due to these facts it follows that such a valve, especially when controlled by a spring, is apt to seat itself the instant after rising, lifting again the next instant in answer to the restored value of the



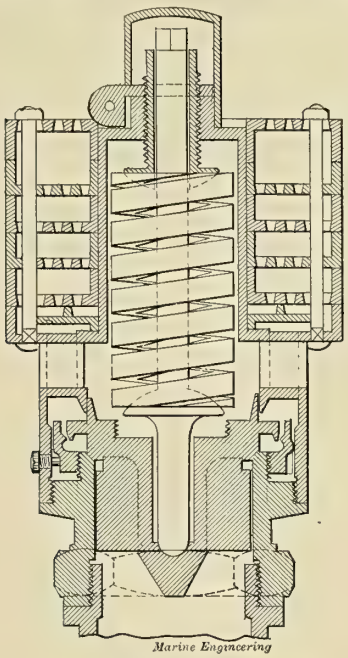
ENLARGED SECTION OF LIP.—Fig. 3.

pressure. This irregular action will lead to a rapid opening and closing of the valve, producing a chattering noise very undesirable in passenger boats, and interfering with the continuous and regular escape of the steam. To avoid this a lip of one form or another, as shown in Figs. 2, 3, and 4, is fitted to the valve at or beyond the edge, so that it may catch the escaping jet of steam, and thus increase the effective area of the valve after it has lifted from the seat. In such case the valve is forced farther from the seat, and while it still vibrates, it remains definitely open until the pressure has fallen some 4 or 5 lb. below that for which it opens. The valve then touches the seat in one of its vibrations downward, and remains closed until the pressure again rises to the point for which it is set. The safety valve should always be fitted with a hand lifting gear, so that it may be opened by hand when desired, and the spring adjustment should be protected by lock and key, so that it cannot be changed by unauthorized persons.

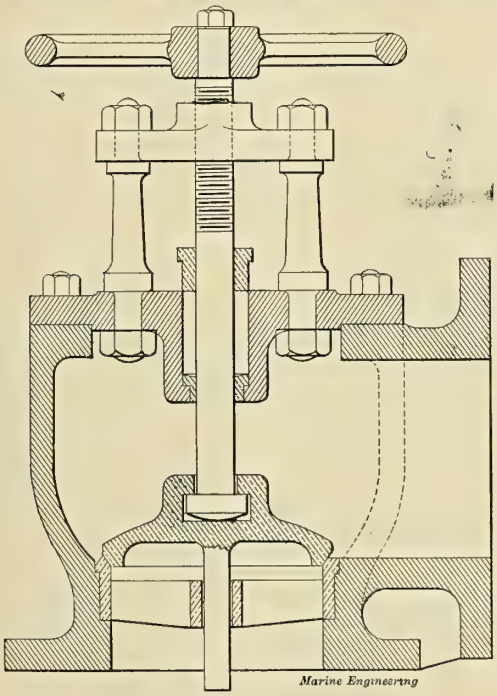
For large boilers, instead of one large valve safety valves are often fitted in groups of two or three. This reduces to the smallest possible limit the danger from sticking or other derangement of the valve. The safety valve or valves should always be attached to a fitting leading direct to the boiler, and with no possibility of closing it off by a stop valve. If both stop and safety valves are attached to the same fitting the latter must

always be placed inside or nearer the boiler than the former.

Muffler.—This fitting, though not in the fire-room, may be properly referred to at this point. It consists of a metal chamber filled with bits of metal or stone, marbles, wire-gauze, small spiral springs, or with thin plates in layers pierced full of holes and arranged in staggered fashion so as to provide a series of zig-zag passages for the steam. The steam from the safety valves and escape pipe makes its way to the air through this chamber, the purpose of the filling being to muffle or deaden the noise, which might otherwise seriously interfere with the giving of orders on deck. Fig. 4 shows a combined safety valve and muffler, the latter with plates as above described. Such an arrangement would be applicable for small or open craft having but one boiler, such as launches, small yachts, etc.



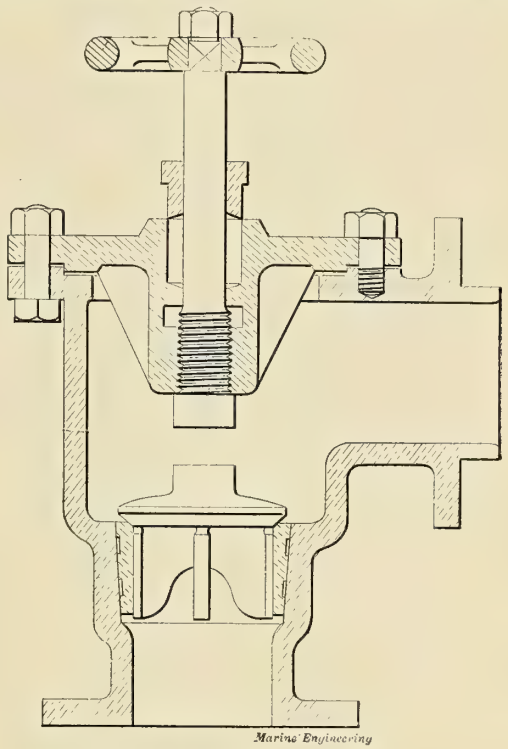
SAFETY VALVE AND MUFFLER.—FIG. 4



BOILER MAIN STOP VALVE.—FIG. 5.

Stop Valve.—Each boiler is connected through a separate boiler steam pipe to the main pipe. The entrance of steam to this pipe is controlled by the boiler stop valve, which thus provides for the regulation of the supply of steam to the engine, and for closing the boiler off entirely from the main steam pipe if necessary. The usual type of valve employed is shown in Fig. 5, and consists of a valve disc guided to its seat by wings, and raised or lowered by its connection with the screw spindle and handle as shown.

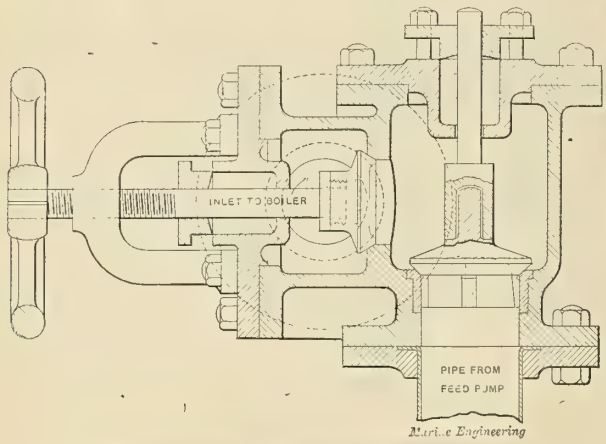
Commonly in warship practice, and to some extent in mercantile practice, such valves are made self-closing in case of rupture of the boiler. In fundamental principle such a valve is a form of *non-return* valve, as illustrated by the check valve of Fig. 6. The screw stem does not open the valve, but limits simply the extent to which the valve can open. A second plain stem passing through the first then allows of the valve being pulled open by hand, even if there is no definite difference of pressure to force it open. In case of accident which reduces the pressure back of the valve so that the rush of steam is in the reverse direction to its usual flow, the valve will be closed by this rush and held securely on its seat by the excess of pressure on its outer face, thus shutting off the injured boiler, and retaining the others intact for use. If such an arrangement is not fitted and the valve cannot be closed by hand, or until it can be thus closed, an entire battery of boilers may be thrown out of use by the rupture of any one of them, all of the



BOILER CHECK VALVE.—FIG. 6.

steam formed escaping through the one opening. Such form of valve should be placed with the spindle horizontal, so that its own weight may not enter as a direct factor in the movement of the valve toward and from its seat.

In warships, where the pipes or boilers may be pierced



COMBINED CHECK AND STOP VALVE.—FIG. 7.

by the fragments of exploding shell, such a safety provision may be of the utmost importance and value.

Dry-Pipe, or Internal Steam Pipe.—This is a pipe of relatively thin metal placed within the boiler, extending lengthwise, and close to the top of the shell. At the inner end it is closed, and at the outer end connects with the pipe leading to the safety valve chamber, stop-valve and boiler steam pipe. Along the top of the pipe are cut a large number of narrow slits, through which the steam enters the pipe. This arrangement has the effect of drawing the steam from the highest part of the steam space, and of straining out some part of the entrained water. A small hole in the bottom of the pipe provides for draining off the water which may gradually collect.

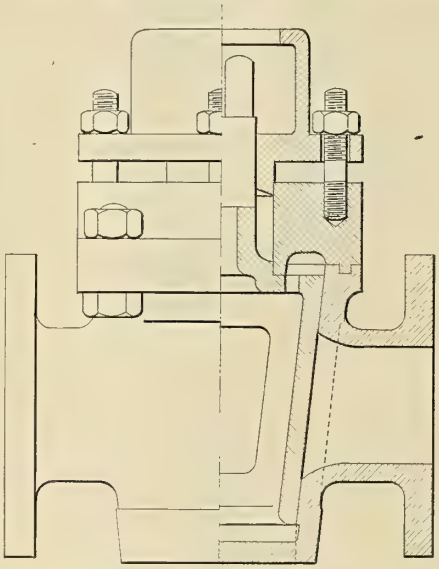
The uniform draft of steam from the whole length of the boiler tends also to prevent the priming which might be caused by drawing it all from one point.

Feed Check Valve and Internal Feed Pipe.—The water from the feed pump comes to the boiler through the feed pipe, and then at the boiler passes through the feed-check. This is a screw-down, non-return valve, as shown in Fig. 6. The valve itself is entirely disconnected from the spindle, and the latter simply limits the height to which the valve can rise, while by screwing down sufficiently the valve may be forced shut and held there. This construction is adopted so that should the feed pump stop working or between the strokes of the pump there may be no escape of water backward from the boiler into the pipe. Two such check valves are usually fitted to each boiler, one connecting with the main and the other with the auxiliary feed pumps.

In modern practice a stop valve is usually fitted between the check valve and boiler, in order that, if necessary for examination or repair, the check may be shut off from communication with the boiler. Such combined stop and check valves are frequently fitted in a single casing, the stop valve, of course, being placed next the boiler (see Fig. 7.)

After passing through the check-valve the water enters the internal feed pipe, by which it is led to the point or points of delivery. The end of the pipe is usually closed, and the water is delivered through a large number of small holes distributed along the pipe. The delivery is usually below the water level, and often between the nests of tubes where it meets with the rising currents of water heated by them. In some cases it is led to the bottom of the boiler, where it mixes with the relatively cool water there found; but this plan cannot be recommended, as it retards rather than assists circulation. In some cases also the water has been introduced as a spray into the steam space, but, while this plan has some advantages, it has not met with general favor.

In water tube boilers the feed water is usually fed into the upper drum, whence it joins the circulation in



BOTTOM BLOW-OFF VALVE.—FIG. 8.

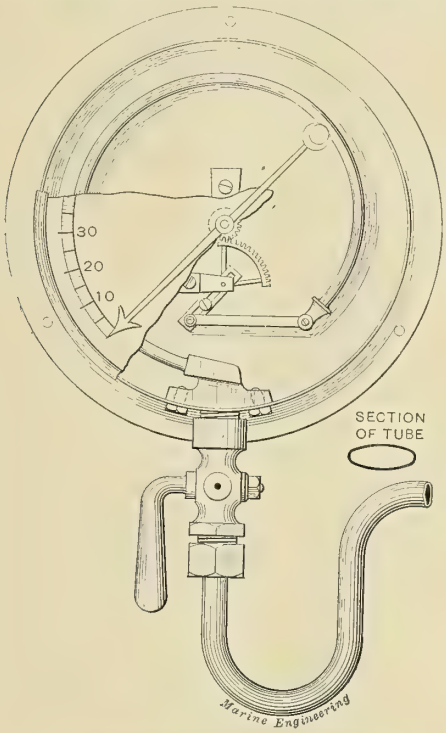
the boiler as noted in the description of boilers of this type.

Surface and Bottom Blows.—Cocks or valves and connecting pipes are fitted for blowing grease and scum, or mud sediment and water, out of the boiler into the sea—Fig. 8. The surface blow is a valve which is attached an internal pipe lying just below the normal water level, and either perforated with holes or leading to a shallow open pan. Outside the boiler there is a discharge pipe leading to an outboard valve, through which the discharge is effected. The scum and grease which collect on the surface of the water may by means of this arrangement be blown out of the boiler, and thus disposed of. In early engineering practice the bottom blow was of great importance, as it was used not only to discharge mud and sediment, but also the relatively dense water in the boiler when blowing down to reduce concentration, or when emptying the boiler of water for purposes of examination or cleaning. In modern practice with the surface condenser and the evaporator, blowing off to reduce concentration is no longer necessary, and blowing the water out of a boiler with its own steam is no longer considered good practice. The preferable plan is to allow the steam to condense and the water to cool down, and to then run it into the bilge or remove it by pump connections suitably arranged. Due

to these facts, bottom blow valves have been sometimes omitted. There may still, however, be occasion to use such valves for the discharge of mud and sediment, and therefore, they are still quite generally fitted. In any event, there should be some valve and pipe connected with the lowest part of the boiler, and through which it can be emptied in one way or another.

Both surface and bottom blows are usually fitted to water-tube boilers, especially to those types consisting of upper and lower drums with sets of connecting tubes. The surface blow is for scum and grease, while the bottom blow is essentially for mud and sediment, and is often attached to a special *mud-drum* provided to collect such substances.

Steam Gauges.—The steam pressure within the boiler, or rather the excess of the pressure within over the atmospheric pressure without, is shown by some form of steam gauge, of which the best-known and most used are those employing a *Bourdon tube*. In Fig. 9 is shown



BOURDON STEAM GAUGE.—FIG. 9.

such a gauge and tube, the cross section of the latter being an ellipse as shown. When the inside of the tube is subjected to the pressure of the steam it tends to become round in section, and as a result of this the tube as a whole tends to straighten out. This carries the free end outword, and this movement, by means of suitable connections, is made to give motion to the needle. These gauges are graduated by comparison with a mercury column or other form of gauge tester, or with a standard gauge which has been thus graduated. Steam should not be allowed to enter these gauges, as the change in temperature may affect the accuracy of the reading. To prevent this the pipe leading to the gauge is always provided with a loop or U bend, called a "goose neck," which serves as a trap for the water condensed beyond this point. In this way the Bourdon tube and part of the connecting pipe are kept filled with water, which in turn is acted on by the steam, and thus the pressure is indicated without the actual presence of steam within the gauge. Steam gauges require comparison with a standard gauge from time to time, in order to make sure that their indications are correct. They are often provided in duplicate, and frequently one gauge, at least, is provided of sufficient range to allow of use in the hydrostatic boiler test.

Water Gauge and Cocks.—The level of the water within the boiler is shown by a vertical glass tube connected to fittings at each end, which in turn connect the one with the steam space and the other with the water space. As shown in Fig. 10, the entire arrangement of glass and fittings is attached to a hollow mounting called the *stand-pipe*, *water-column*, or *water-gauge mounting*. To the top and bottom of this are attached pipes, one leading to the steam space at or near the top, and the other to the water space at or near the bottom. In connecting the pipe with the steam space care must be taken that the opening is not near a steam outlet, as the rush of steam past such an opening might disturb the pressure and render the indications inaccurate by showing a higher level of water in the glass than actually exists in the boiler. At the bottom of the mounting a drain cock and pipe are provided, so that the glass may be blown through and cleaned as occasion requires. Screw plugs are also fitted above and below in a line with the base of the tube, so that if necessary a wire and swab may be run through the glass. Instead of the connections as shown in Fig. 10, and which are to be considered as preferable, the ends of the water column are sometimes connected by horizontal passages directly to the boiler, as in Fig. 11, which shows the fitting attached to the curved shell of boiler. With such a mounting the level of water in the glass is more liable to fluctuation and disturbance due to rolling of the ship or to priming than with the arrangement of Fig. 10.

Gauge glasses are usually from 12 to 15 in. in length, and 5-8 or 3-4 in. dia. Due to the fluctuations in temperature and the accompanying expansion and contrac-

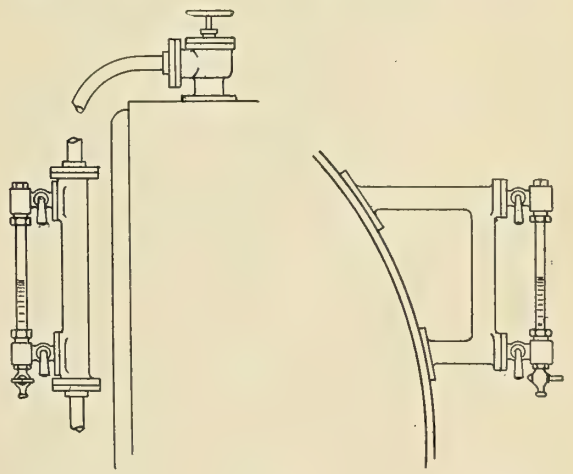


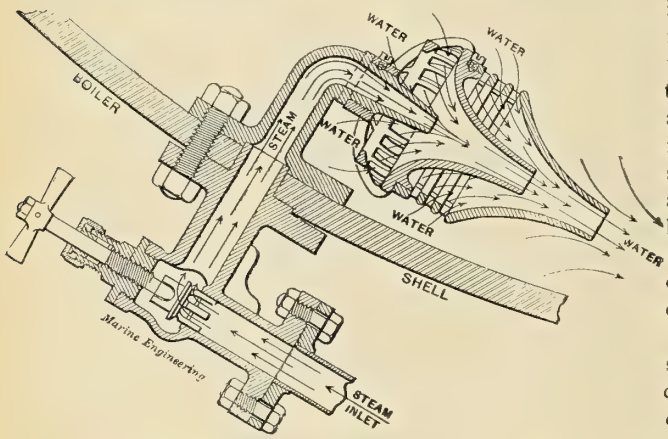
FIG. 10. WATER GAUGES. FIG. 11.

tion, they are liable to occasional breakage. To avoid danger or trouble from the escaping jet of water and steam, it is quite customary in modern practice to fit the connection carrying the ends of the glass with ball non-return valves, working on a similar principle with

the safety stop valve described above. So long as the glass is in place and the pressure equalized, the balls by their weight remain away from the seat and leave the passages open. Upon the breakage of the glass, however, they are carried by the rush of water and steam, each against its seat, thus closing the openings and stopping the escaping jets of water and steam.

In addition to the gauge glass, small cocks, three or four in number, are usually provided. In some cases such cocks are attached to the mounting, and in other cases to the boiler itself. These cocks serve as a check on the gauge glass, or for use in case the glass is not to be depended upon. The glass is usually so adjusted that when the water is at the bottom it is still some 3 or 4 in. above the level of the highest heating surface. The water cocks cover about the same vertical distance, though in some cases the lowest cock is placed nearly on a level with the top of the heating surface. On single-end boilers two such water gauges are often fitted, one on either side at the front, and with water cocks at the back. Similarly on double-end boilers three would be fitted, two on one end and one on the other.

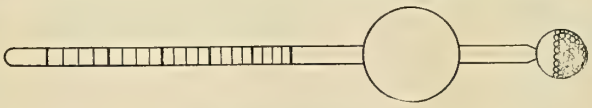
Hydrokineter.—This is an appliance used to force the circulation of the water in the boiler, more especially



HYDROKINETER.—FIG. 12.

when raising steam. It consists, as shown in Fig. 12, of a steam jet and series of nozzles with frame perforated at the back for the entrance of water. The steam is furnished from another boiler, and by its inducing action a current of water is set up and driven along, as shown by the arrows. This arrangement is placed near the bottom of the boiler, and thus serves to drive out the cold water which tends to collect there, and which is only slowly heated by the operation of natural circulation.

Hydrometer.—The density of the water in the boiler is determined by an instrument known as the *hydrometer*, and shown in Fig. 13. It may be of either glass or metal, and consists essentially of two bulbs with stem as shown. The upper and larger bulb is filled with air, and serves to give buoyancy to the instrument; while the lower and smaller bulb is weighted and keeps it in the upright position. When a body floats freely, wholly or partly immersed in a liquid, the weight of the body equals the weight of the liquid displaced. Hence, in this case the denser the water the less the volume displaced, and the higher the stem out of water. Average sea water contains about 1 part in 32 of solid matter, and hydrometers are usually graduated relative to this as a unit. That is, 2 means twice as much solid matter relatively as sea water; 3, three times as much, etc., while 0, of course, means fresh water. The density of water depends, furthermore, on its temperature, so that the scale on the hydrometer can only be used with the temperature for which it was graduated. This is usually 200 deg. F., though frequently three scales are provided; for 190 deg., 200 deg. and 210 deg., respectively. The water is drawn from the boiler through an appro-



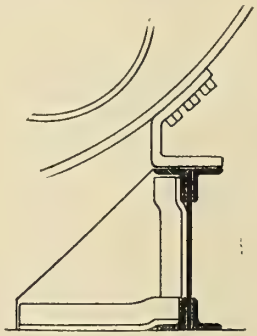
HYDROMETER.—FIG. 13.

priate pipe and connections into a deep, slender vessel the hydrometer scales, and thus its density is observed.

Boiler Saddles.—The weight of the boiler is supported on *saddles*, or *bearers*, which in turn are attached to the structure of the ship. A modern form of boiler saddle is shown in Fig. 14, and consists of two or more supports on each side of the boiler of the form shown, and extending each one for some little distance longitudinally. An older form consists of a plate on edge connected with the structure of the ship, extending transversely under the boiler, and cut out to fit the round of the shell. The upper edge of this plate is fitted with angle irons on one or both sides to give a broader surface of support for the boiler. The form of saddle shown in Fig. 14 gives a better longitudinal support, and, moreover, makes access and examination of the bottom of the boiler more easy than with the other form. Single-end boilers usually have two such saddles on each side, while double-end boilers are given three or four.

In addition, the boiler is held in place in its saddles by stays adjustable by screw turnbuckles, or by other like

called a *salinometer pot.* Soon after drawing, the water cools down through the temperature corresponding to



BOILER SADDLE.—FIG. 14.

means. A knee-piece, or chock, is also often riveted to the structure of the ship, projecting just above the end of the boiler at the bottom, and thus preventing endwise motion.

Boiler Lagging.—To prevent loss of heat by radiation the boiler is covered with non-conducting, non-combustible felting, which in turn is held on by iron straps, or in some cases by a complete covering of sheet metal. This covering is known as *boiler lagging.*

THE ART OF MAKING MECHANICAL SKETCHES —FOR MARINE ENGINEERS—X.

BY PROF. C. W. MAC CORD.

All that precedes has reference to the making of drawings (or sketches, as the case may be), in which each view represents only one face of an object, as seen from any given direction. One such view can at best give positive information in relation to two dimensions only: as height and length, if it be a front view; height and breadth, if it be a side view; or length and breadth if it be a top (or "plan") view. In order to give the necessary information as to all three dimensions by means of such drawings, therefore, as we have seen, in many if not most cases three views are required, and not infrequently more than that. And for the general purposes of working drawings, either of details or assembled machines, the methods of construction heretofore explained are admitted, we believe, by general consent to be the best. Nevertheless, there are cases

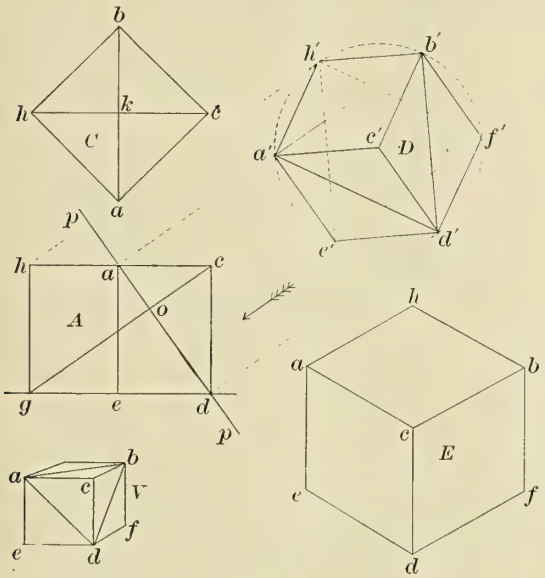


FIG. 43.

in which some method of giving in one view an accurate idea of the three dimensions is very desirable.

A true perspective drawing does not meet the requirement; for, to say nothing of the extreme difficulty of construction, it is impossible to make definite measurements from it, no matter how clear an impression it may give of the general proportions and arrangement. Pictorially, however, it has no equal, since all visible parts are shown in proper relative positions, in true relative proportions, and without distortion; in short, just as they would appear to the eye from the point of view selected.

There are, however, more methods than one of exhibiting the three dimensions in one view, and thus producing an effect of solidity and relief which is lacking in the "working drawings" thus far considered, without incurring the labor of making a true perspective; at the expense, it must be admitted, of a greater or less amount of distortion of one kind or another. Still, these methods are at times very useful; more particularly in making sketches from which working drawings are subsequently to be made in the ordinary way.

The first of these will be understood by the aid of Fig. 43; in which *A* is a front view of a cube, so placed that, as seen in the top view *C*, the diagonals *ab*, *ch*, of its upper face are respectively perpendicular and parallel to the paper. Now let this cube be cut by a plane *pp*, passing through the three points *a*, *b*, and *d*; this plane will contain the three face diagonals *ab*, *ad*, and *bd*, as seen in the small perspective view *V*, and since in the front view *ab* is perpendicular to the paper, the plane will there be seen edgewise. Moreover, it can be shown that this plane is perpendicular to the body diagonal *cg*, which is itself parallel to the paper; for, in the top view we have *ke* : *ca* :: *ca* : *ab*; and again,

Kc of the top view = *ac* of the front view,
ac " " " " = *cd* " " " " "
ab " " " " = *dg* " " " " " ;

whence, in the front view, *ac* : *cd* :: *cd* : *dg*, consequently the triangles *acd*, *cdg*, are similar; but also *ac* is perpendicular to *cd*, and *cd* is perpendicular to *dg*, and it follows that *ad* is perpendicular to *cg*.

Now the view *D* is an *orthographic projection*, being a view of the cube as seen looking perpendicularly against the plane *pp*, as shown by the arrow. In this view the three face diagonals above mentioned will appear of their true lengths as *a'b'*, *a'd'*, *b'd'*, because they lie in the plane *pp*; the three edges, *ca*, *cb*, *cd*, are equal in space and equally inclined to the plane *pp*, hence they will in the view *D* be equally foreshortened and appear of equal lengths, and the point *c* will appear as *c'*, the centre of the triangle *a'b'd'*. In a similar manner it may be shown that the points *e*, *f*, and *h* will appear as the vertices of the equilateral triangle *e' f' h'*, whose centre coincides with *c'*, which is also the projection of *g*. Since then all the edges of the cube appear of equal lengths, this has received the appropriate name of an *isometric projection*. It is sometimes miscalled *isometric perspective*, and also erroneously described as an *oblique projection:* whereas, as above shown, it is in fact simply an orthographic projection upon a peculiarly placed plane.

The lines *c'a'*, *c'b'*, *c'd'* are called the *isometric axes;* the planes which they determine, and all planes parallel to them, are called *isometric planes;* and all lines parallel to the axes are called *isometric lines.*

In Fig. 43, the actual length of the edge of the cube is *cd*, while its projection *c'd'* is equal to *od*. Therefore, by taking *od* as a unit instead of *cd*, an *isometric scale* might be constructed, by which the lines of the projection might have been set off, or by which the isometric lines in such a projection might be measured. Were such a proceeding *necessary*, the utility of this special kind of drawing would be practically destroyed. Fortunately, however, it is not necessary; since all the edges of the cube are equally foreshortened, there is no reason why they should be shown as foreshortened at all; and, accordingly, in Fig. 43, an *isometrical drawing* of the cube is made as shown in the view *E*, where each edge of the cube is shown in its true length, which is *cd* in the original elevation *A;* the isometric axes *ca*, *cb*, *cd*, making with each other angles of 120°, as in view *D*.

Drawings made in this manner, then, convey in one view ideas of the three dimensions, as do those made in perspective; in some cases they exhibit the peculiarities

of structure more clearly than the regular "working plans;" they are readily understood by many who are not familiar with common projections, and in making sketches they are often very useful.

But from the foregoing exposition of its principles, it will be quite obvious that the advantages of isometry

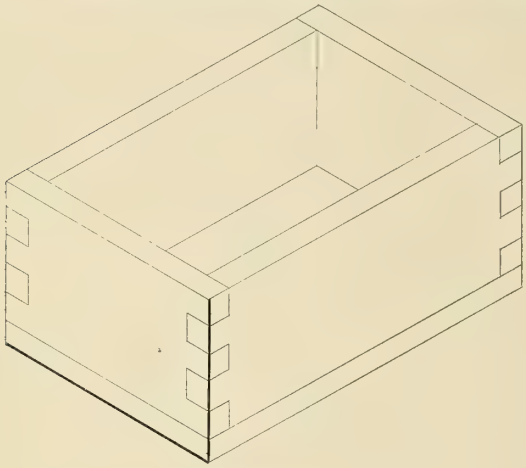


FIG. 44.

are more pronounced when the objects to be represented are bounded by right lines, of which the principle ones are respectively parallel and perpendicular to each other. This is clearly illustrated by the drawings of the box, Fig. 44; of the timbers with tenons and mortise, Fig. 45; and of the piece of flooring with its supporting beams, Fig. 46.

No dimensions are here given; but it is clear that since none but isometric lines are represented, the dimensions should be given in directions parallel to the isometric axes. And, again, if the object be too large

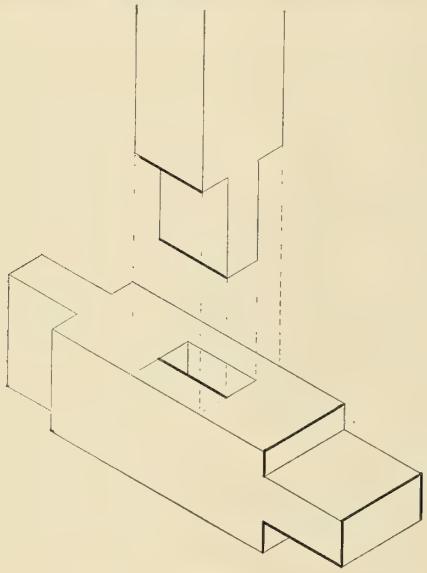


FIG 45.

to be drawn with the dimensions of their true length, we are at liberty to make an isometrical drawing, just as we may any other orthographic one, on any convenient scale, as 3 in. equal 1 ft., 1 1-2 in. equal 1 ft., and so on: in fact, to quote from the late W. E. Worthen, "the value of isometry as a practical art lies in the applicability of common and known scales to the isometric lines."

But though admirably adapted for making sketches or working drawings of "square" work like that shown in the last three figures, isometry is not equally advantageous in the representation of machinery in general, for this reason if no other; that every circle lying in an isometric plane is represented by an ellipse. A method of constructing this ellipse, which is both accurate and convenient, is shown in Fig. 47. The circle inscribed in the front face of the cube in the elevation *A*, is divided into quadrants by the vertical and horizontal centre lines, and the quadrants are bisected by the diagonals at the points *l, m, n, o;* through these points are drawn vertical and horizontal lines. All these right lines are readily drawn in the isometric view *D*, thus locating the points *l', m', n', o';* the required ellipse must pass through these points, and also be tangent to the sides of the circumscribing parallelogram at their middle points. And since this parallelogram is a rhombus, its diagonals are perpendicular to each other, so

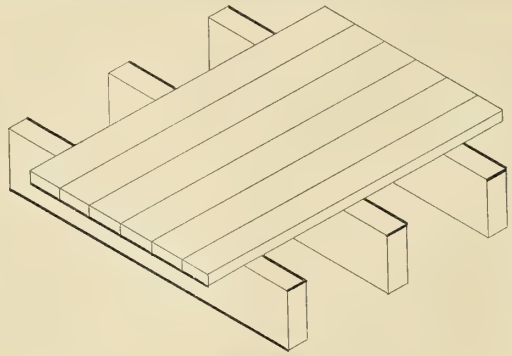


FIG. 46.

that *o'm'* is the major, and *l'n'* is the minor, axis of the ellipse.

If tangents to the circle be drawn at *l, m, n, o,* cutting off the corners of the square, the circle will be circumscribed by a regular octagon; the isometric representation of which is made by drawing at *l', o'*, etc., perpendiculars to the diagonals. If similar perpendiculars be drawn to the diagonals of the adjacent faces, as shown, these will determine a plane perpendicular to the body diagonal of the cube through *c*, by which that corner of the cube may be cut off. If this process be repeated at the other corners, the result, as shown in Fig. 48, will be an isometric drawing of the crystalline form known as the "cubo-octahedron," bounded by six equal octagons and eight equal equilateral triangles. This affords an instance in which this mode of representation is much clearer and more striking than that of the ordinary front, side, and top views; as any one may easily convince himself by making a comparative construction.

Referring again to Fig. 47, it is to be observed that it is not necessary to draw the elevation *A* in order to construct the ellipse in the isometric view *D*. For if a semicircle be drawn on the edge *cd* as a diameter, divided into four equal parts at *1, 2, 3,* and these points of subdivision be projected perpendicularly upon *cd*, the isometric lines through the points *1', 2', 3'*, will, by their

intersection with the diagonals, locate the points l', m', n', o'. Since all the edges of the isometric cube are equal, this construction may be made upon either indifferently—and again, since the faces of the cube are

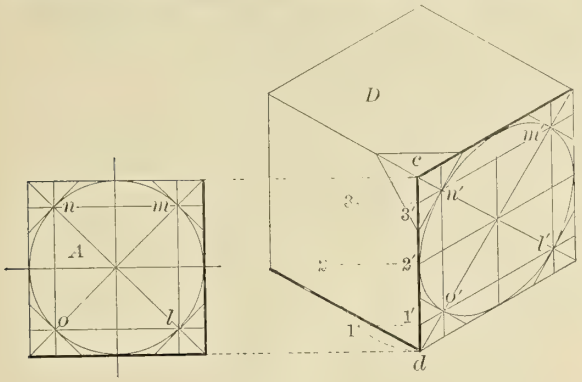


FIG. 47

isometrically represented by similar and equal rhombuses, the isometric representations of circles inscribed in all these faces will be equal and similar ellipses.

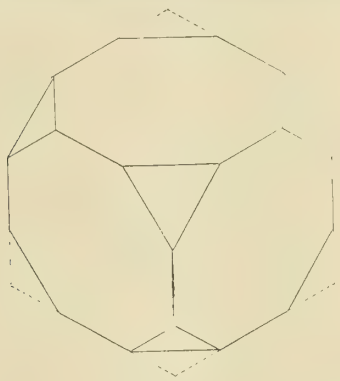


FIG. 48.

In Fig. 49 are shown two methods of graduating the isometric circle, represented by the ellipse inscribed in the rhombus *acbd*.

First Method.—At *e*, the middle point of *db*, draw *ef*,

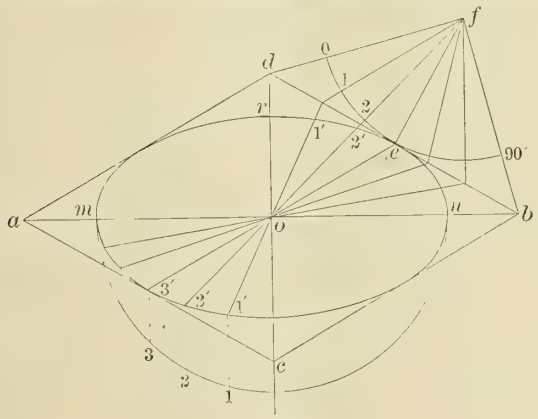


FIG. 49.

perpendicular to *db*, and equal to $eb = ed = eo$: then $dfb = 90°$. About *f* describe a quadrant with radius *fe*: graduate it as desired, and draw through the points of division radii from *f*, as *f1*, *f2*, etc., and prolong these radii to cut *bd*: from the points of intersection draw lines to *o*, the centre of the isometric circle; these will cut the perimeter in *1'*, *2'*, etc., thus giving the required graduation.

Second Method.—About *o*, the centre of the ellipse representing the circle, describe a semicircle whose diameter is *mn*, the major axis. Graduate this as desired, by the points *1*, *2*, *3*, etc.; from these points draw perpendiculars to the major axis *mn*, cutting the perimeter of the ellipse in *1'*, *2'*, *3'*, etc. Lines from these latter points to *o*, the centre of the ellipse, will include the representations of equal angles, if the semicircumference upon *mn*, as a diameter, is divided into equal parts.

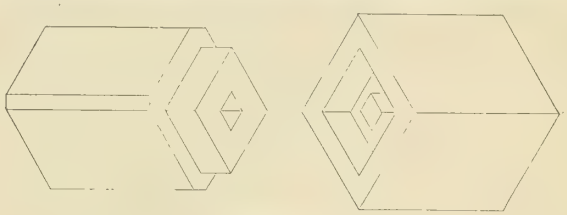


FIG. 50.

Thus far, one of the isometric axes has been assumed to be vertical. But since it is the relative inclination of the isometric lines to each other which determines whether a drawing is or is not an isometric one, it follows that any direction at pleasure may be given to either one of these axes. Thus, in Fig. 50, one of them is horizontal, and it is very apparent in this case that the correspondence of the die to the matrix is more clearly shown by exhibiting their opposite faces than could have been done in any other way. By turning the page a quarter round it will be seen that this could have been done equally well if the two pieces had been placed upright. Which leads to the consideration that isometry sometimes affords peculiar facilities for the illustration of subjects where views of the lower surfaces are desirable; as in the case of the shelf with its brackets in Fig. 51.

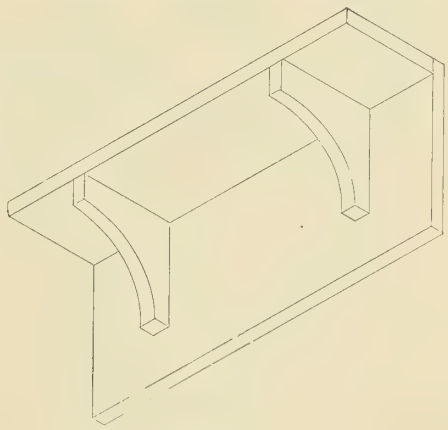


FIG. 51.

Of course, there will often be occasion to represent lines which do not lie in isometric planes. A method of dealing with these is illustrated by the drawing of the partially opened box, Fig. 52—and perhaps as well as it could be by any other subject. A sectional end elevation of this box is given below the isometric drawing;

and few words are needed to explain the construction of the latter. The non-isometric line $b'd'$ is determined by setting off on the vertical through c', the distances $c'a'$, $c'e'$, respectively equal to ca, ce, in the elevation, and then drawing parallel to the isometric axis $c'x'$, the offsets $a'b'$, $e'd'$, equal to ab, ed; then drawing $c'd'$, we have two sides of the parallelogram representing the

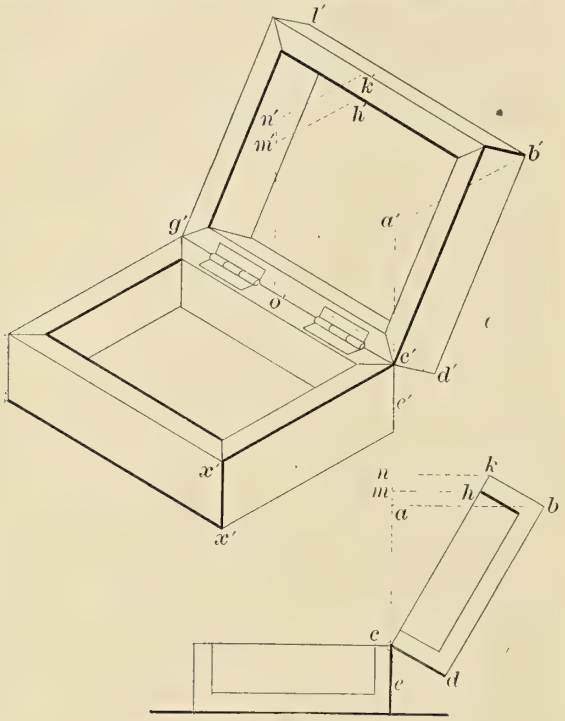


FIG. 52.

nearer end of the lid, which, though lying in an isometric plane, is bounded by non-isometric lines. To determine the apparent thickness of the front side of the lid, we may set up at any point o' on $c'g'$, the distances $o'm'$, $o'n'$, respectively equal to cm, cn, in the elevation, and then draw $m'h'$, $n'k'$, parallel to $c'x'$, and equal re-

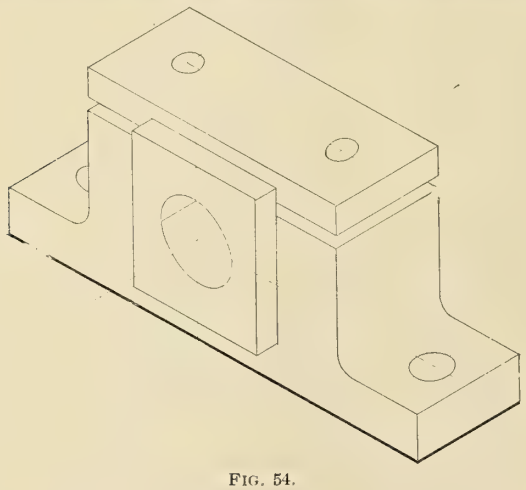


FIG. 54.

spectively to mh, nk, in the elevation. The thickness of the remote side of the lid may be determined in like manner. There is little more to be said, since it is apparent that all the longitudinal lines of the lid are isometric lines: thus $b'l'$ is equal and parallel to $c'g'$, etc., and all the others are parallel to either $c'd'$ or $b'd'$. This method of determining the extremities of non-isometric lines by means of offsets is always applicable, and, in fact, it is simply the application to isometry of the familiar method of locating a point in space by means of the ordinates drawn from the given point to the planes of projection.

But, though often useful in making sketches, isometric drawing is not well adapted to the general representation of machinery, not only because many, if not most, of the circles involved must be represented by ellipses, but on account of a very unpleasant apparent distortion, which will be at once appreciated by a glance at Fig. 54, which is an isometric drawing of the pillow-block shown in plan and elevation in Fig. 53. This is but a minor case. The distortion becomes more aggravated and pronounced with the complexity of the mechanism; so that it may be accepted almost as a truism, that isometry is not well adapted to the representation of assembled machines, however serviceable it may be in the making of sketches and in the representation of minor details.

This topic should not be dismissed without some illu-

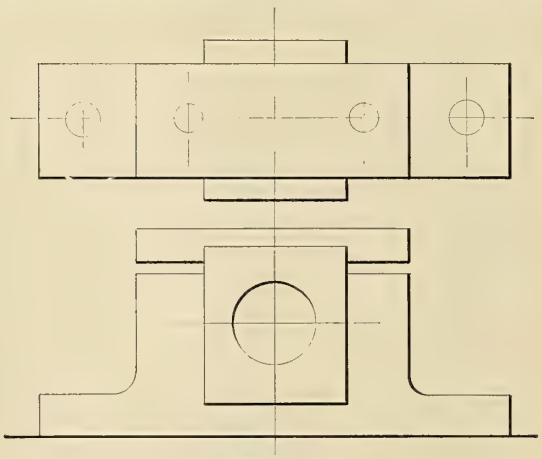


FIG. 53.

sion to the use of shadow-lines in isometric drawings. In relation to this (referring to Fig. 43) it is, we believe, a common practice to consider the light as falling in the direction of the body diagonal through a toward f in the view E. In that case the upper side and the left side of the cube would be illuminated, while the face bd would not be. In these circumstances, the edges cb, cd, de, and, in point of fact, bh, would cast shadows. We have purposely mentioned bh last because, in our opinion, it should not be made a shadow line at all, for the very object of shadow lines is to produce the effect of relief, and make the lines thus distinguished seem nearer the eye than others; whereas bh is conspicuously the most remote line in the drawing.

It is proper to give bc and cd a moderate thickness, since they are nearer to the eye than bh, and they do cast shadows, supposing the light to fall as above indicated. But on the other hand, they are the intersections of planes, both of which are visible in each case; and on this account the thickness of the line casting the shadow should be but a very little greater than that of the ordinary outline. There remains, then, the line

de, to which the preceding arguments do not apply: but again, this beyond question is apparently a receding line, and nothing could more effectually destroy the impression that it is so than the very common error of inking it in with a bold, broad stroke.

Finally, then, all considerations point to one conclusion—that in isometric drawings the shadow lines should be manipulated with a leaning to the side of mercy, and never be made of so pronounced and emphatic a character as they may properly be made in the execution of ordinary "working plans," such as have previously occupied our attention.

NEW PUBLICATIONS.

The volume for 1900 of the Record of American and Foreign Shipping, which is the thirty-second annual issue of this valuable register and classification of shipping, is now being delivered to subscribers. The Record contains full reports and particulars of about 17,000 vessels of all classes and nationalities; rules for the construction and classification of steel, iron, and wooden vessels; rules for the construction and survey of steam machinery and boilers for vessels; provisions for the installation of electric lighting and power apparatus on shipboard, and much other valuable information of special importance to underwriters and all firms or persons interested in shipping. Besides the usual full information for the benefit of subscribers in the way of rules for construction with accompanying illustrations and tables—all of practical value—the work contains such features as list and addresses of prominent shipbuilders, dry docks, marine railways, marine machinery and boiler constructors in the United States; list of vessels whose names have been changed; also compound names, indexed by the last name; names and addresses of owners of vessels classed in the Record. The work is approved and endorsed by the important boards of underwriters in the United States, and is accepted by merchants and underwriters throughout the world as a standard register and classification of shipping. This excellent index has been thoroughly revised to date, and contains a large number of classifications not included in previous issues. The new Record is published by the American Bureau of Shipping, No. 37 William street, New York.

The Royal Navy List Diary and Naval Handbook for 1900 has just been issued by Witherby & Co., 326 High Holborn, London, price by post, three shillings and eight pence. For those having use for such a work it is an excellent combination of diary—one page 6 in. by 9 in. for each day—calendar and information needed by mariners. Naval matters are also given a good deal of mention, and this includes a sketch of "Naval Progress of the Year," by L. G. C. Laughton. To this is added a valuable comparative table of battleships of the first class of all the great naval powers, which gives totals of vessels built or building as follows: Great Britain, 45; France, 17; Russia, 15; United States, 12; Italy, 12; Germany, 10; Japan, 6. Another feature of real value is the Astronomical Summary which occupies several pages. The diary is bound in boards.

The small revenue cutter *Seminole*, for service at New York harbor, has been completed at the Columbian Iron Works, Baltimore, Md.

ENGINEERS' DICTIONARY.—XXIII.

Indicator—An instrument by means of which a cylinder using steam or other vapor, gas or liquid is made to give its own history of the continuous relation between pressure and volume throughout the stroke. The card or diagram thus drawn shows whether the valve gear is working properly in its distribution of the steam to the cylinder, and furnishes likewise the means for computing the *indicated horse-power*. The operation of the instrument requires two main features. (1) A movement proportional to that of the piston, and (2) a movement proportional to the steam pressure at any instant. The first movement is communicated to a strip of paper and the second to a pencil moving at right angles to the first. The diagram resulting will, therefore, show continuously the relation between piston position and pressure as desired. In Fig. —, showing an indicator, *A* is a light drum, which is given a motion of rotation about its axis by means of a cord wound around its lower end as shown, and attached at the other to a piece having motion proportional to that of the piston. The circumference of the drum is usually from 3 to 5 inches, so that the movement of the piston must be reduced in proportion before connecting with the drum cord. The device which accomplishes this is known as the *reducing motion*, and by its means the drum moves back and forth in constant proportion to the movement of the piston. The strip of paper is attached to this drum by means of clips, as shown, and thus the first of the necessary motions is obtained. *B* is a cylinder within which is a nicely fitted piston. The steam is admitted below the piston, thus urging it upward, while a coiled spring fitted above balances by its compression the varying pressure of the steam. In order to avoid distortion of the diagram as a result of the inertia of the piston in its motion up and down, it is found desirable to have the motion of the piston itself quite small, and to magnify this by a system of light levers, *E*, called the *pencil motion*, and carrying at the extremity the pencil point which traces the diagram on the paper. These springs are carefully adjusted, so that the vertical motion of the pencil shall be proportional to the pressure of the steam per square inch, and according to convenient scales, with

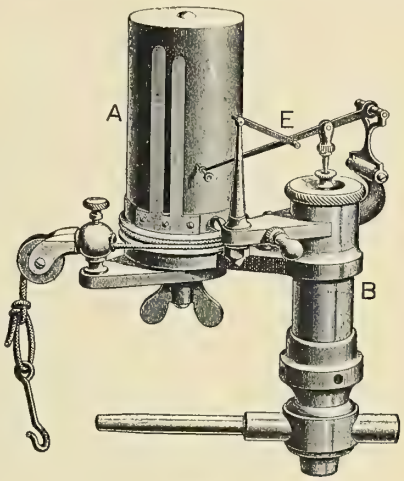


FIG. 82.

which each spring is marked. These scales may vary from 10 to 100 lb. per inch or higher, according to the pressure employed. The pencil motion is so mounted and attached to the piston-rod that it may be moved about horizontally without disturbing the action of the steam on the piston. By this means the pencil may be moved up to the drum or withdrawn from it as may be desired. In taking a card the drum cord may first be connected with the reducing motion, and the steam then admitted to the indicator cylinder. When everything is working properly the mounting of the pencil motion is swung about the cylinder until the pencil point rests lightly on the paper for one revolution (or longer if desired), and the operation is complete. After thus taking the card it is customary to draw the *atmospheric line,* or line of atmospheric pressure. To this end the cock which closes off the steam is so made that when closed it also connects the space below the piston with the air. The pencil being then brought up to the card, the desired line is traced. See PQ, Fig. 81.

Indicator Barrel—A term frequently applied to the drum of the indicator, as before described.

Initial Pressure—The pressure in the cylinder of an engine at the beginning of a stroke.

Injection—A general term used in reference to the condensing water for the condenser of a steam-engine, or to its admission to the circulating pump.

Injection Valve, Cock, Pipe, etc.—See INJECTION.

Intermediate Cylinder—In a multiple expansion engine one of the cylinders, into which the steam passes from the first or high pressure, and before reaching the last or low pressure. See ENGINE.

Internal Feed Pipe—The continuation of the feed pipe inside of the boiler to the point or points of discharge.

Inverted Engine—A vertical engine with the cylinder above and crank-shaft below, as in the usual marine type. See ENGINE.

QUERIES AND ANSWERS.

(Communications intended for this department will not receive attention unless accompanied by the full name and address of the sender, which will be considered confidential.)

Q.—What is the benefit of or objection to tail rods?

MARINE ENGINEER.

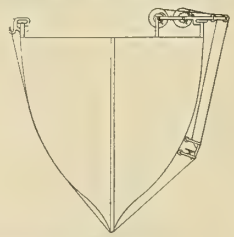
A.—The use of tail rods is a matter on which a considerable difference of opinion exists. Some builders use them and others in similar cases do not, but in general tail rods do not appear to be as extensively used at the present time as in former practice. When the cylinder diameter is large, and the stroke short, tail rods are undoubtedly of service in preventing tilting of the piston in the cylinder. Large pistons often wear the sides of cylinders unevenly when the crosshead wears out of line, and the tail rod is intended to prevent this. In merchant practice one chief objection to them is the increased number of stuffing boxes to be packed, though in these days of perfect metallic packings this objection should be more on the score of cost than trouble. To get rid of the stuffing boxes tail rods have been frequently incased in a pipe with flanged end, bolted on to the cylinder top at the lower end and closed at the upper end. The rod passes through a composition bushing in the cylinder cover up into the pipe. Small engines are also frequently fitted with tail rods, such as those on tugs. In the case of horizontal engines tail rods are of use in keeping the weight of the piston off the bottom of the cylinder. We believe they are used on modern locomotives to some extent, and on large horizontal stationary engines they are sometimes fitted with a shoe on the outer end working in a slide.

SELECTED MARINE PATENTS.

(Subscribers are notified that the publication of a patent specification in this column does not indicate editorial commendation or condemnation.)

634,329. Diver's stage for cleaning ships' hulls. W. P. Freeman, New York, N. Y., assignor to the Electric Stone Cleaning and Renovating Company, Jersey City, N. J.

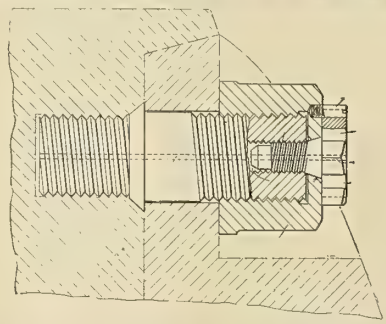
CLAIM.—An adjustable seat or stool within an open frame, which is supported from the deck of the vessel



by ropes connected to windlasses. By means of the ropes the frame is guided and moved along the hull.

633,376. Means for securing propeller blades. Lewis Davies, Liverpool, England.

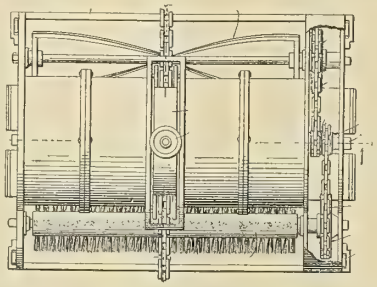
CLAIM.—Improvements reside in details of the construction of the studs and cap-nuts. The studs screwed into the boss are each formed with a longitudinal pas-



sage and a screw-threaded hole, a reversely-threaded cap-nut is formed with the central aperture, and a set-screw is inserted through this aperture into the hole in the stud.

633,910. Machine for cleaning ships' bottoms. John Schnepf, New York, N. Y., assignor of one-half to W. C. Doscher, same place.

CLAIM.—Within a frame adapted to be passed under and around the hull of the vessel by means of a cable



are a scraper and a brush and an electric motor to drive them. It is claimed that the iron in the body of the vessel will attract the magnets of the motor and hold the device close to the ship.